A Technical Report

Open Ocean

Creating Marine Models for Museum Exhibition

Adrienne Aikins

ROYAL
BRITISH
COLUMBIA
MUSEUM

Province of British Columbia
Ministry of Tourism and
Ministry Responsible for Culture

92-06050/

Copyright © 1992 by the Royal British Columbia Museum.

All rights reserved. No part of this book may be reproduced or transmitted in any form by any means without permission in writing from the publisher, except by a reviewer, who may quote brief passages in a review.

Published by the Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia, V8V 1X4, Canada.

Printed in Canada.

Illustrations by Adrienne Aikins.
Edited and designed by Susan Down.

Canadian Cataloguing in Publication Data
Aikins, Adrienne.
Open Ocean

At head of title: A technical report
ISBN 0-7718-9203-9

1. Marine fauna - Models - Handbooks, manuals, etc. 2. Museum techniques - Handbooks, manuals, etc. I. Royal British Columbia Museum. II. Title.

QH90.7.C3A34 1992 574.92'075'3 C92-092200-7

PREFACE

The Open Ocean exhibit was unveiled at the Royal British Columbia Museum in January 1987, after two and a half years of preparation. This ambitious $2.3 million project required a staff of 18 technicians to construct the 206 models. Some of the models, including species from surface, midwater and bottom zones, were created to animate an undersea diorama. Other more detailed models (some twice actual size) were created for didactic showcases.

Each specimen presented its own set of challenges, requiring technicians to use innovative solutions where there were no documented guidelines for construction. For example, unique problems were posed by the installation of photophores to create a bioluminescent effect. Months of experimentation led to high standards of reproduction, especially of difficult features such as eyes and multi-coloured flesh tones.

In this manual, the techniques used to create the 32 different species in the Open Ocean exhibit have been presented in 10 groups, ranging from the simplest to the most complex. These techniques can be adapted for many uses such as reproducing archeological artifacts as well as biological specimens.

Adrienne Aikins

The following people worked on the project:

Project Leader	Donna Warren
RBCM Sculptor	Chris Denbigh
RBCM Exhibit Model Makers:	Adrienne Aikins Ross Brand Mary Brownscombe Carol Christianson Gordon Harper Doug Sage Pat Scott Buddy Williams
Contract Model Makers:	Debbie Bates Dar Churcher Richard Gibson Laura Hargrave Philip Linfield John MacIntosh Chris Munsen Sandra Ritter

CONTENTS

I **Making Moulds from Sculpted Models** 1

II **Deep Sea Skate**
A. Making a one-piece mould 2

III **Roughscale Genadier**
A. Making a two-piece mould 6
B. Casting a solid epoxy model in a two-piece mould 10
—single colour to be surface painted 10
—multi-colour in the mould lay-up 16
C. Making eyes with lenses 19

IV **Flapjack Devilfish**
A. Making a small glove mould 23
1.Freeform mould 23
2.Poured mould 26
B. Casting a small hollow epoxy model 31

V **Blue Shark**
A. Making a large glove mould 34
B. Casting a large, hollow, epoxy model 41
C. Making large, vacuum-formed fins, assembling and finishing 44

VI **Northern Lampfish**
A. Making a small, hollow, vacuum-formed model with simple eyes 46
B. Installation of bioluminescent effect in a small model 49

VII **Coho Salmon**
A. Bending a large, solid, epoxy model for vacuum-forming models 55
B. Painting and finishing a vacuum-formed diorama model 56
C. Casting a hollow, epoxy model using a rotational molder 58
D. Silvering technique for an epoxy fish model 62

VIII **Vampire Squid**
A. Installation of the bioluminescent effect in a large model 64

IX **Flat Sea Cucumber**
A. Casting a PVC model 71

X **Deep Sea Whip**
A. Assembling a PVC model from separately cast pieces 73

XI **Deep Sea Jellyfish**
A. Making and casting moulds for a semi-transparent, multi-layer model 76
B. Forming acrylic tentacles 80
Appendix: Materials, manufacturers and suppliers 81
Glossary 84
Index 86

Making Moulds from Sculpted Models

1. Models for the Open Ocean exhibit were cast in moulds made from original sculptures. To cast accurate models in lifelike, active poses, sculptures were created in Sculpy by referring to the museum's preserved specimens as well as written and photographic sources. Sculpy is similar to plasticine in appearance and consistency but it can be hardened by curing with heat. After being cured the sculptures can be easily handled and moulds can be made from them. The moulds were not made directly from specimens because of several problems inherent to marine specimens:

   (a) The tissues of marine specimens tend to be high in water content and quite soft in structure. When submerged, the animals are supported by the surrounding water since the atmospheric pressure is equalized inside and outside of the specimens. When they are removed from the water, their shapes often distort and/or collapse. Even sturdier fish that appear fairly normal when removed from the water lose some of their characteristic contours while submerged, particularly after they die.

   (b) The methods for collecting marine specimens, especially drag nets, damage them even further, abrading delicate skins and breaking off appendages.

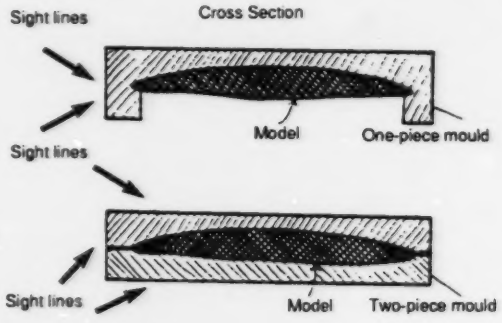
   (c) The specimens are preserved in alcohol or formalin. During the preserving process, the chemical replaces the water in the tissues and some shrinkage and more distortion occurs.

   (d) The high salt content in marine specimens can inhibit the chemical reactions in many mould-making materials causing serious problems when attempting to take moulds directly from the animals.

DEEP SEA SKATE *(Bathyraja trachura)*

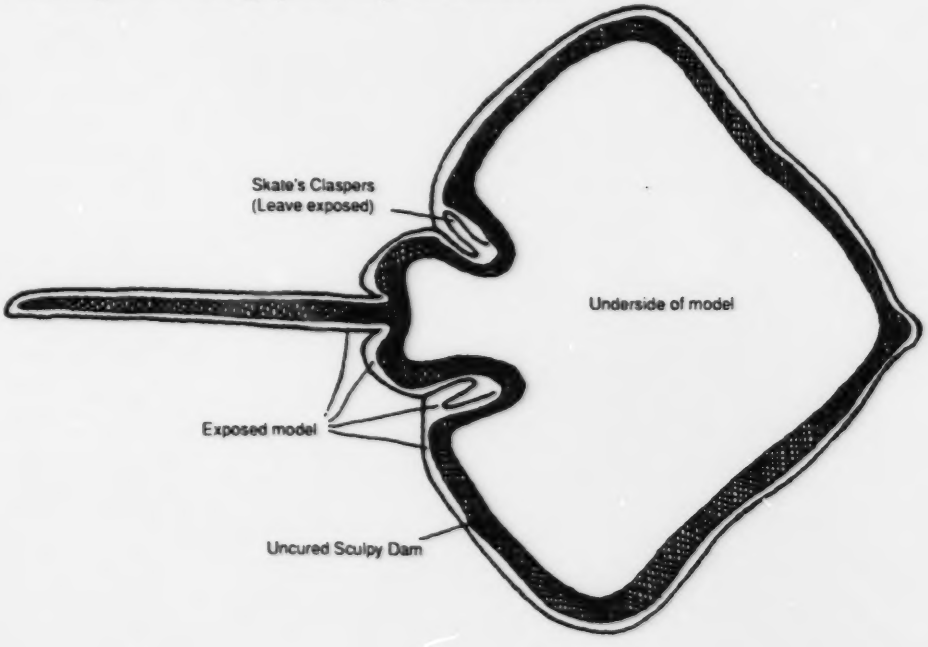
Making a One-Piece Mould

1. The model is to be mounted and displayed as though the skate is gliding just above or resting on the ocean floor. It is very flat with only the dorsal (top) surface and a very small portion of the underside, visible. As the mould needs to have detail only in these visible areas, a one-piece mould can be made of the Sculpy sculpture. If more of the underside was to be shown, or if more than one side or plane of the model was visible, a two-piece mould would be necessary.



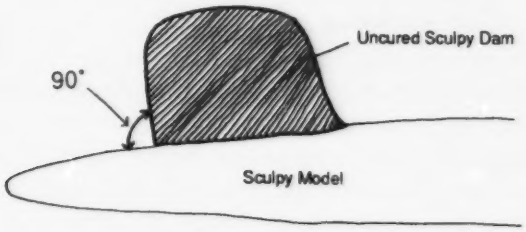
2. Turn the sculpture upside down, exposing the underside, and fully support it. Be very careful not to damage the dorsal surface. A plastic bag partially filled with Styrofoam beads is a good support. Use uncured Sculpy (See: Making moulds from sculpted models) to make a "dam" on the underside of the model 3 mm to 6 mm (1/8" to 1/4") in from the outside edges. Leave the skate's claspers exposed. The mould-making material will cover the areas on the model left exposed outside the Sculpy dam. Build the dam 6 mm to 13 mm (1/4" to 1/2") high and about 25 mm (1") wide.

   Seal the dam to the model by gently pushing the Sculpy into place with a modelling tool. Carefully shape the outside edge of the dam to make a crisp, clean line. This edge should form a 90° angle to the sculpture. Thoroughly clean any excess uncured



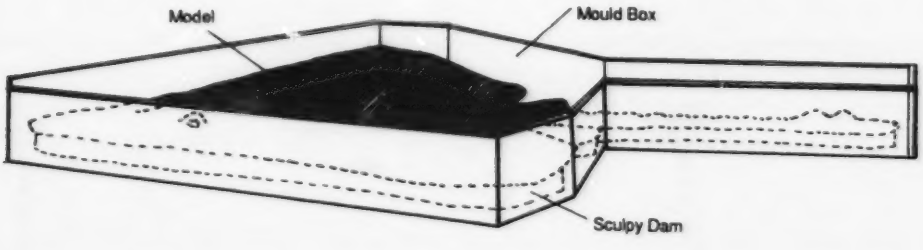
fill in unnecessary spaces and reduce the volume of rubber needed to fill the box. The box can be made from wood, plywood, particle-board, cardboard, Fome-Cor or other similar material.

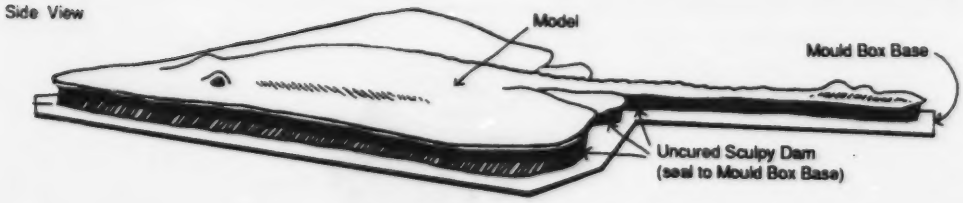
4. This mould box will be made from 4.5 mm (3/16") Fome-Cor. It is a graphic arts board consisting of a foamed plastic sheet laminated between two sheets of hard-surfaced paper. Cut out the mould box



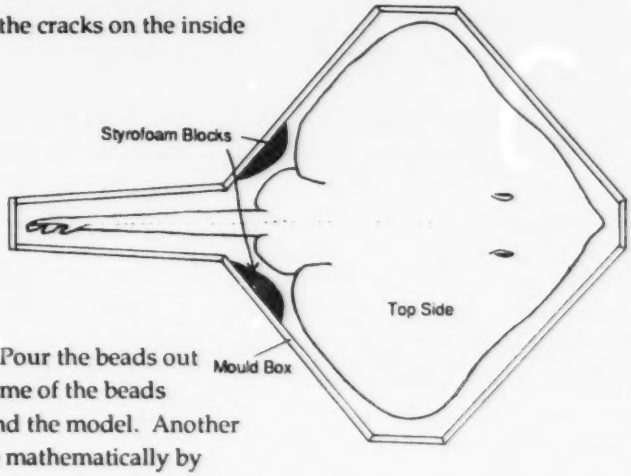
base, making it about 25 mm (1") larger than the skate all the way around. Position the base over the Sculpy dam on the skate and gently press down. The Sculpy dam is now sandwiched between the mould box base and the skate sculpture. Very carefully turn the model, dam and base over together. The base is now on the bottom and the model is right side up. Carefully seal the dam to the base using a modelling tool. Check that the dam is still sealed to the model and fix any areas that may have separated.

5. Measure and cut the sides of the mould box from Fome-Cor. Make the height of the sides equal to the thickness of the model and the Sculpy dam plus about 25 mm (1"). Assemble the sides around the base. Cover the joins on the outside with masking tape to hold the box together. This also seals



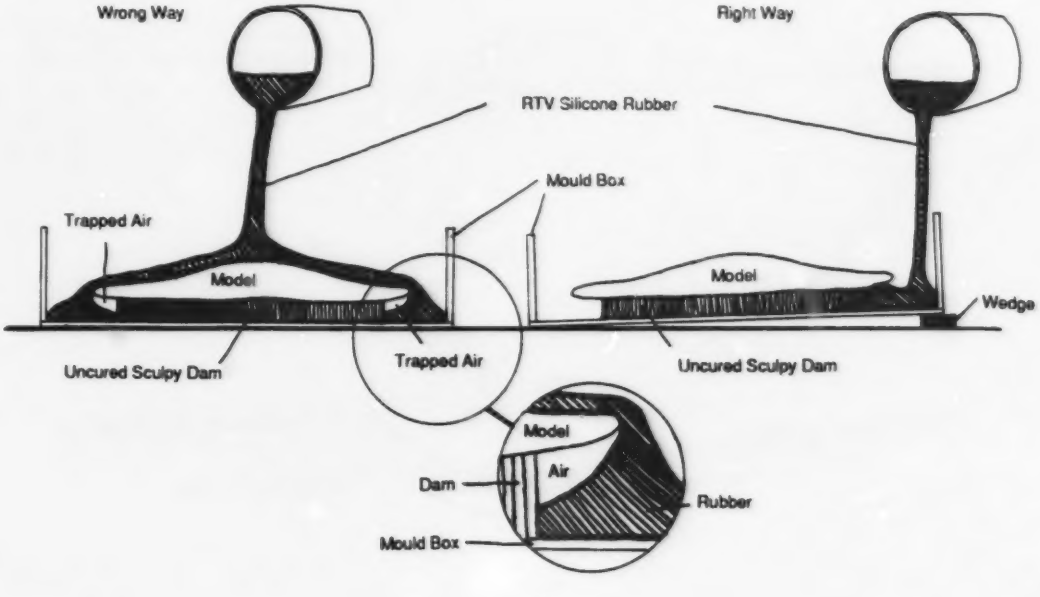


the cracks so the rubber will not leak out. Seal the cracks on the inside with uncured Sculpy.



6. Calculate the amount of RTV silicone rubber required to fill the mould box to a level that completely covers the sculpture. This can be accomplished in different ways. One method is to pour 3 mm (1/8") of Styrofoam packing beads into the mould box, covering the model's highest point by about 13 mm (1/2"). Pour the beads out of the box into a graduated container. The volume of the beads equals the volume of the space in the box around the model. Another method is to calculate the approximate volume mathematically by dividing the various areas in the box into imaginary cubes, multiplying length by width by height and adding all the answers. After the volume is calculated, add about 10% more to the total amount because some rubber always adheres to the mixing tools and the sides of the mixing container. Rubber should never be scraped off these into the mould because the catalyst may not be thoroughly blended into that rubber and it may not cure properly. Also, scraping rubber from the tools and sides of the mixing container into the mould mixes air into it which may not be able to escape. If the rubber cures around an air bubble it forms a void in the mould. If the void is on the surface of the model, it will appear as an imperfection. (Murphy's Law ensures that it will be in the worst possible location!)

7. At this point, a decision is made as to which RTV silicone rubber will be used to make the mould. For the Open Ocean Gallery models, either Dow Corning Silastic "E" or Silastic "J" were used. The mould-maker has to become familiar with the properties of the different varieties of RTV silicone rubber to judge which will best suit the needs of each project. Information and specification charts are available from the manufacturers.



8. Weigh the rubber and calculate the amount of catalyst required. For Silastic "E" and "J", mix 10 parts rubber to one part catalyst by weight.

   Mix the rubber and catalyst together very thoroughly because they must blend mechanically; portions that are not evenly blended may not cure properly. Since the mixing process beats a lot of air into the rubber, keep the mixing blade submerged in the rubber at the bottom of the bucket. Put the rubber into a vacuum chamber and evacuate the air from the chamber. The rubber will expand to about three times its volume before collapsing, so vacuum it in a vessel large enough to contain that expansion. Evacuate the chamber for about half an hour. If the rubber is not vacuumed long enough, it will still contain too many bubbles. If it is vacuumed too long, there may not be sufficient time to pour the mould properly before the rubber begins to cure.

9. Begin pouring the rubber into the box *very slowly*, in as thin a stream as possible. Start in one corner and allow the rubber to flow out slowly, rising up and over the model. Do not pour directly onto the model because that increases the chances of trapping air in undercuts which creates a voids in the mould. The mould box can be wedged up slightly, at the end that the rubber is being poured into, so that gravity can help move the rubber along.

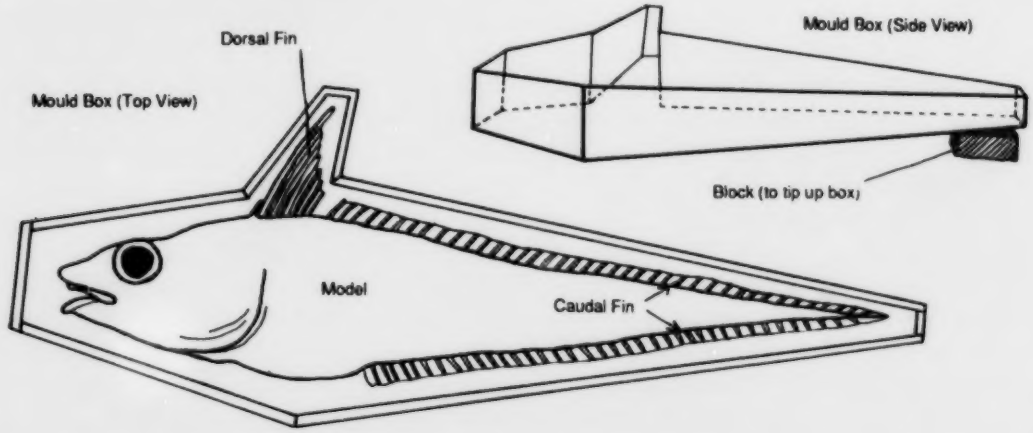
   RTV silicone rubber cures at different rates—faster at higher temperatures and slower at lower temperatures. To increase the working time of the RTV silicone rubber, divide it into more than one container before vacuuming. The extra portions can be refrigerated until they are required for the pour. The cooled rubber will initially flow more slowly than rubber at room temperature but it will flow longer because it will begin to cure later than the warmer rubber. Pouring the mould is one of the most crucial phases in the whole process. The chances of a successful mould are greatly increased if the pour is preplanned and slowly, carefully executed. Continue pouring the mould until the model is covered to a depth of 13 mm (1/2") at its highest point. Marks can be made on the inside edge of the mould box, before the mould is poured, to indicate the desired depth. Take out the wedge and let the mould sit (preferably on a vibrating surface to help any trapped air bubbles migrate out) and break any bubbles that rise to the surface. Allow the mould to cure at room temperature (at least 12 hours for Silastic "E" or "J"). The curing time can be heat accelerated, but let the rubber sit for at least one to two hours before heating to ensure that it has flowed into all the model's indentations and to give any air bubbles a chance to move up and away from the model's surface. The mould can then be baked in an oven at around 38–65° C (100–150° F) for two to three hours. The manufacturer provides specification charts which describe the parameters of the various RTV silicone rubbers.

10. After the mould is completely cured, disassemble the mould box and remove the Sculpy dam. Carefully remove and save the Sculpy model. If the moulding material or the mould fails, it may be possible to salvage and repair the original Sculpy model to make a second mould of it. The original model can also be useful as a reference while casting the mould and for teaching mould-making techniques. Thoroughly clean the mould. The mould is now ready for casting.

ROUGHSCALE GRENADIER *(Coryphaenoides acrolepsis)*

Making a Two-Piece Mould

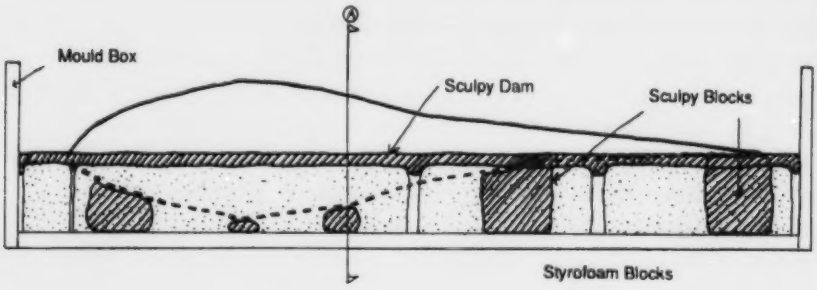
1. Make a mould box (See: Deep Sea Skate, step 3). All sides, top and bottom should be easy to assemble and disassemble. RTV silicone rubber moulding material is expensive so the box should be only as large as is necessary. This will also ensure that the mould is as light as possible. The sides of the box must be deep enough to contain the entire width of the model with about 13–25 mm (1/2"–1") extra to allow for complete coverage of the thickest part of its body. (In this case, the area of the pectoral fin stumps where the pectoral fins have been removed.) Fish models often have fins that stick out at various angles to the main body shape. This increases the complexity of the mould design and in some cases would make it very difficult to remove the cast fish from the mould without damaging either the cast or the mould. These fins can be carefully removed from the sculpture and separate moulds made from them. Because this model is so large and the mould will be relatively heavy, the box should be made from reasonably strong materials. Use 13 mm (1/2") particle board or plywood and assemble it with 19 mm (3/4") drywall screws. Cracks and joins can be sealed with uncured Sculpy before pouring the mould.

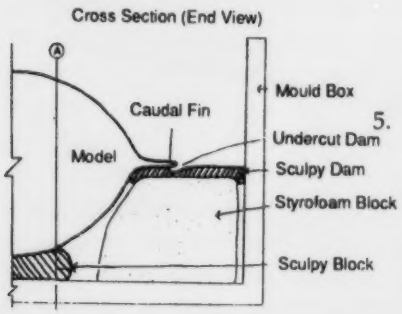


2. Remove the sides of the mould box for easy access. When the model is seen in profile, there is a view-side and a back-side. It is best to first mould the side that will be viewed when the model is exhibited because the cured rubber will protect it from possible damage during the rest of the mould-making procedure. Lay the Sculpy model on the bottom section of the mould box, facing up. Use pieces of Styrofoam or Sculpy to support the model at two or three points so that it is raised at its thickest point (pectoral fin stumps) by at least 6 mm (1/4") above the base. When pouring the mould, the horizontal axis of the model should be as close to level as possible. If the model is not level when placed in the box, you can tip the mould box at one end to compensate. Due to the drastic variation in the thickness of this particular model, tipping the mould box saves a substantial amount of molding rubber.

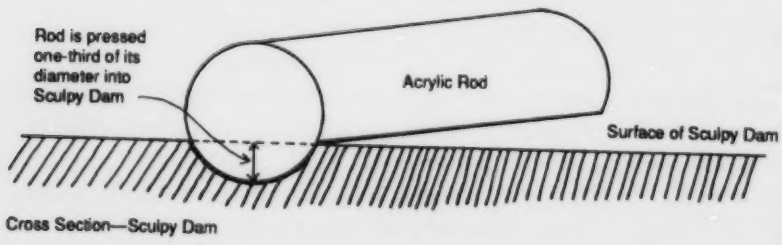
3. Fill the gross spaces under the model with pieces of Styrofoam (e.g., under the dorsal fin and under the caudal fin). Use more pieces to fill in the smaller gaps between the model and the box bottom.

4. More detailed damming should be done with uncured Sculpy. Dam very carefully. Undercut the Sculpy dam slightly under the back-side of the caudal fin. (See diagram below— End Cross Section) This locates the seam on the back-side of the fin where it won't be visible. Hide the seam on the dorsal surface of the head by situating it slightly to the rear of the halfway line, beyond its viewing sight line. Sight lines can be ascertained by looking at the Sculpy model in the position that it will be viewed when exhibited. The ventral seam can remain in line with the lower caudal fin, veering backwards at the lips to meet with the dorsal seam. Sculpy should be pressed up firmly against the model in order to seal thoroughly but should not be rubbed against it as this will cause filling in of detail and will require tedious cleaning before the mould is poured. Carefully work all the Sculpy damming to a smooth finish. The two halves of the mould will fit together best where points of registration are crisp, clean lines. Small pits & mounds on the Sculpy surface may be just enough to keep the two mould halves from fitting together snugly.



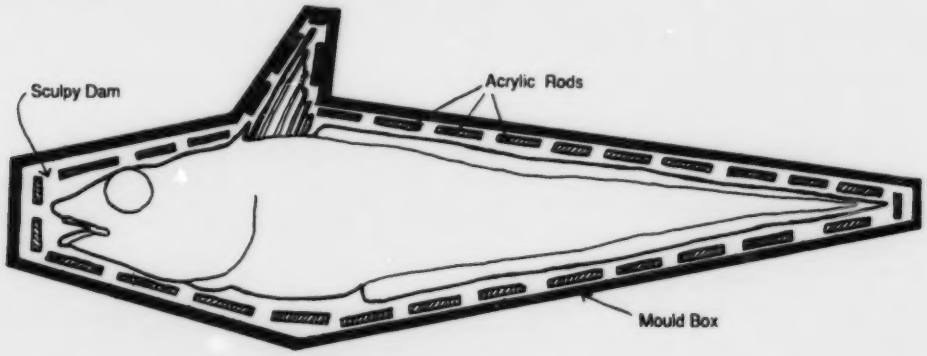


5. Gently press strips of 13 mm (1/2") acrylic rod into the flat areas of the Sculpy dam within 13 mm (1/2") of the model all the way around its perimeter. Tool the Sculpy so that it seals along the edges of the rod. Use short 10–12 cm (4"– 6") straight sections of rod with about 25 mm (1") gaps between them. This will create registration in all directions. Prerounding the ends of the rods on a grinder avoids tears in the mould from sharp edges when removing the rods at a later stage. The rods should be depressed to one-third of their diameter. After the mould is poured, the rods will be removed, leaving indentations (the shape and size of two-thirds of the rod) in the cured rubber. When the second half of the mould is poured, the rubber will flow into these indentations and form protrusions. These indentations and protrusions are female and male registration "keys" that fit together perfectly. With this type of registration, the two halves of the mould should actually snap together in an exact, snug fit. Using rods is



not appropriate for small moulds where there isn't enough space to embed the rods in the Sculpy dams. For smaller moulds, registration can be facilitated by making half-spherical impressions into the flat areas of the first half of the Sculpy dams. This will also produce male and female registration keys.

6. Determine the amount of two-part RTV silicone rubber required to completely cover the view-side of the model (See: Deep Sea Skate, step 7 and 8). Mix the rubber and curing agent according to the directions on their containers and place the mixture in a vacuum chamber to remove the trapped air bubbles. This takes about half an hour. If the rubber is vacuumed for too long, it can begin to cure before the mould is completely poured. It is important, however, to be thorough when vacuuming (See: Deep Sea Skate, step 9). While removing the air from the rubber, assemble the sides of the mould box. Blow off all dust from the view-side of the model and its dam with compressed air. When very few air bubbles remain in the rubber, remove it from the vacuum chamber. Use compressed air or a pin to burst any bubbles visible on surface.



7. This model has a very large variation in thickness from head to tail. By tipping the mould box, and blocking it under the tail end, a substantial amount of rubber can be saved. Very slowly, in as thin a stream as possible, begin pouring the rubber into the mould box. Start in a corner, as far away from the actual model as possible, and allow the poured rubber to flow out slowly up and over the model rather than pouring directly onto it. This method should reduce the possibility of trapped air creating voids in the undercuts (See: Deep Sea Skate, step 10). Continue pouring until the model is covered to a depth of at least 13 mm (1/2") at the thickest point (pectoral fin stump area). Let the mould sit, preferably on a vibrating surface, and break air bubbles as they rise to the surface. Continue this monitoring for half an hour to an hour or until no more bubbles appear. Cover it to keep out dust and allow it to cure undisturbed for at least 12 hours (See: Deep Sea Skate, step 11). **Do not accelerate curing with heat applications above temperatures of 100° F if Styrofoam was used in the damming process because the Styrofoam will melt.**

8. When the rubber is fully cured, attach the top board and turn mould box upside down. Remove the bottom (now on top) board and all the Styrofoam and Sculpy damming. Be careful not to damage the original model. Remove the acrylic rods from the mould. Attach a 25 mm (1") piece of acrylic rod, extended upwards from the model's eyeball. Hold it in place on the eyeball with Sculpy. This will make a pour spout for casting purposes. Blow off small bits of Sculpy and dust with compressed air. Take extra care with any small undercuts and the registration indentations. The rubber and model surfaces should be absolutely clean when finished.

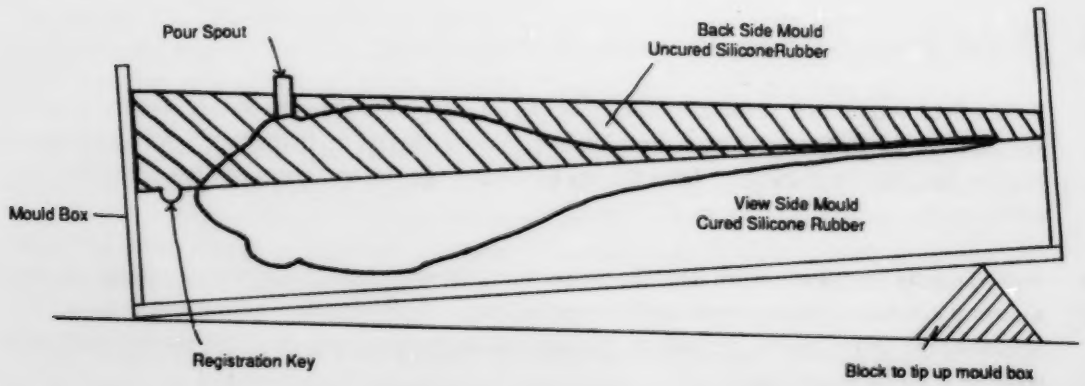
9. Make a toluene/Vaseline release agent. Melt **one part Vaseline** over low heat. Remove from heat and add **10 parts toluene**, mixing until the solution is clear (or slightly milky) and thoroughly combined. Heat slightly if the Vaseline gels again before mixing is completed. Heat this in a pan of hot water because the mixture is inflammable and must not come into contact with the heat source.

10. **VERY IMPORTANT! The two halves of the mould will not separate without a release agent.** Paint the toluene/Vaseline solution liberally onto the mould's exposed surface. The surface should feel oily but a slick should not be visible. Make sure that all the detail is coated, but not filled (a couple of coats may be necessary), including the mouth cavity and the registration indentations. Carefully brush or wipe off any excess. Clean again with compressed air.

11. Pour the second half of the mould using the same procedure as for the first half of the mould.

12. When the rubber is cured, pull the mould halves apart and remove the acrylic rod pour-spout and the original Sculpy model. Clean as much Sculpy out of the mould as possible. For a model with very intricate textures, such as the Roughscale Grenadier, a thin lay-up of fibreglass-backed epoxy may be the quickest and most thorough way to clean the mould. That lay-up would be discarded.

13. Fish models often have fins that stick out at various angles to the main body shape. This increases the complexity of the mould design and in most cases would make it very difficult to remove the cast fish from the mould without damaging either the cast or the mould. These fins can be carefully removed from the sculpture and separate moulds made from them. The fins are cast in these separate moulds and attached to the cast model during its finishing. If the fins will be viewed with only one surface visible, a one-piece mould can be made. All fins, excepting the dorsal and caudal, were removed from this model before the mould was made. Make one small mould box with sides and a bottom (no top) for each fin. A box made with Fome-Cor and masking tape will be strong enough. Lay the fin view-side up in the box. A small ball of Sculpy placed in the centre of on the underside of the fin will secure it in place on the bottom of the box. Carefully press the fin flat to the bottom. Blow off any dust or debris. Pour silicone rubber into the box to a depth of 3–6 mm (1/8"–1/4") above the top of the fin. After the rubber has cured, remove the fin from the mould and clean the mould.



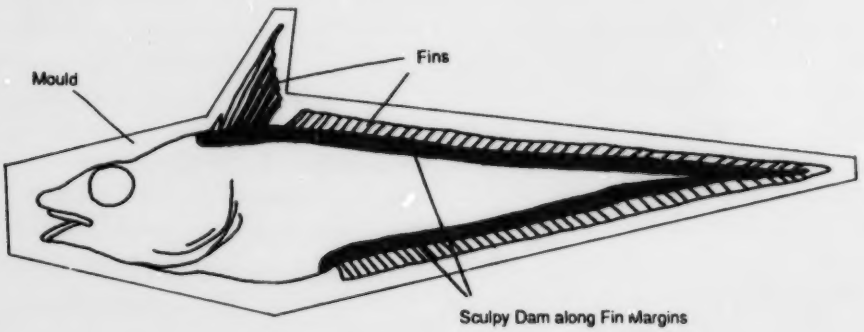
ROUGHSCALE GRENADIER *(Coryphaenoides acrolepsis)*

Casting a Solid Epoxy Model in a Two-Piece Mould —Single Colour Surface Painted

(SEE: ROUGHSCALE GRENADIER, page 6)

1. **HEALTH HAZARD WARNING**

   Epoxy resins and their hardeners are toxic through skin absorption and highly toxic through inhalation. They are potent skin sensitizers and irritants causing acquired allergic reactions as well as asthma, coughing, bronchiospasm, and other respiratory difficulties. The resins are similar in structure to some suspected carcinogens (cancer causing agents) and, therefore, are under suspicion themselves. They also contain solvents of varying toxicity that can cause liver and kidney damage. To avoid accidental contamination and ingestion, do not eat or drink in the work area. Wear eye protection and non-permeable gloves. Avoid ANY skin contact. Wash regularly with warm water and soap, not with solvents. Not only are solvents absorbed through the skin themselves but they remove the skin's oils which act as a natural barrier to toxin absorption. Use sufficient local exhaust ventilation or a window exhaust fan and always wear an approved organic vapour respirator while working with epoxies. (Source: *Artist Beware* by Michael McCann, PH.D , Watson-Guptill Publications/New York)



2. Clean the mould. Plug the eye/pour hole with uncured Sculpy.

3. Build a Sculpy dam in the central cavity, along the fin margins of the view-side half of the mould. This dam keeps the brownish black tinted epoxy, that will be laid up in the fins, from running back into the body cavity of the fish. After the fins have been laid up, and the epoxy has cured, the body will be cast in cream-coloured epoxy.

4. Spray Frekote 700 release agent onto the mould along the fins areas. Since Sculpy will not adhere to a surface to which a release agent has been applied make the Sculpy dam before spraying on the release agent. After the fins are laid up, the dam will be removed and the entire mould cavity will be sprayed with the release agent.

5. Mix a small amount of Nu-clear epoxy (50% A to 50% B). Mix the epoxy in plastic beakers and not waxed cups, as the wax has been suspected to inhibit the epoxy's curing in some cases. Add one drop of Flo-out surface tension breaker to the epoxy to prevent fish-eyeing. Flo-out makes the epoxy slightly cloudy so it should not be used if a clear layer is desired. Tint the epoxy with a very tiny amount of black and brown pigment. The mixture should be filmy, not opaque, so that the fins will appear translucent to transparent between their rays. The fins are a warm grey colour.

6. Paint the epoxy onto the fins with an inexpensive brush (brushes used for heated epoxy lay-ups tend to have a short life expectancy). Push it up into the fin rays and coat over the edge of the Sculpy dam (to prevent epoxy leaking under the dam in subsequent lay-ups). Heat the epoxy in the mould with a heat gun. The epoxy will become thin and runny and then thicken again as it cools. Brush the epoxy to remove any air bubbles and to distribute the coating evenly. Continue to heat and to brush until the epoxy starts to become tacky (referred to as the "toffee" stage). When the epoxy begins to cure, it will no longer thin readily with heating.

7. The mould can be left at room temperature for four hours to cure or it can be put into an oven at less than 63°C (135°F) to accelerate the curing time.

8. Repeat the lay-up process until the fin rays and the levels between the rays are the same height. Do not build up the fins too high or the two halves of the mould will not fit together snugly, causing leakage when the cast is joined. For the same reason any excess epoxy should be cleaned off the edges of the mould after each epoxy layer is applied.

9. Remove the Sculpy dams from the body cavity of the mould. Clean the mould thoroughly and spray it with Frekote 700 release agent. Mask the cast fins so that no release agent is applied to the previously laid up epoxy. This would interfere with the fins adhering to the epoxy of the cast model's body.

10. Mix a cream-coloured pigment, using ochre and white pigment, with a small amount of Nu-clear "A" resin. Make up enough pigment mixture to use in all the lay-ups so that the colour will be consistent.

11. Mix "A" and "B" parts Nu-clear epoxy, one drop of Flo-out and a small amount of the pigment mixture together thoroughly. Brush on a thin layer of this mixture over the entire mould impression (excluding the already cast fins). Lay up both halves of the mould at the same time. Heat the epoxy with a heat gun and use a brush to release any air bubbles and evenly distribute the epoxy.

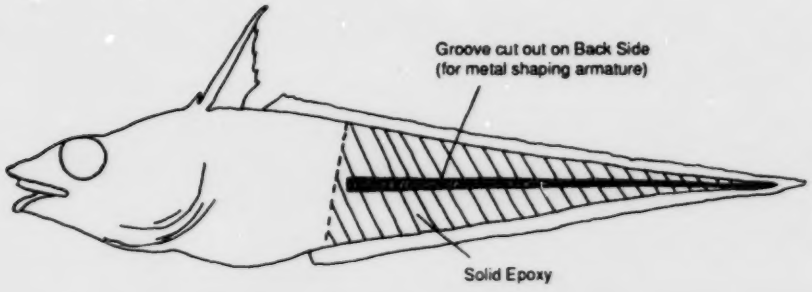
    If fish-eyeing occurs, subsequent layers will cover any voids. Once the epoxy reaches the "toffee" stage, the mould can be put into an oven at 65°C (135°F) for half an hour to accelerate the cure. The next layer of epoxy can then be applied. It is important for each layer of epoxy to be completely cured before the next layer is applied otherwise the uncured layer of epoxy will lift off the surface when heat is applied to the next layer.

12. Repeat this process until all of the scales are completely covered. Aerosil filler can be added to the epoxy mixture to obtain a more viscous epoxy but this should only be applied in the head and body areas—not the tail—because filled epoxy is more rigid and brittle while the tail will be bent at a later

stage. The last couple of layers can have angel veil fibreglass mat worked into them in the body area for strength. This isn't needed in the head or tail because these areas will be solid.

13. Scrape and smooth the edges of the epoxy so that the two halves of the mould can fit together snugly.

14. To estimate the amount of epoxy needed to fill the mould cavity, look at the view-side half of the mould. Draw imaginary lines making a cube of the head and then calculate volume (multiplying length by width by depth). Add some extra volume because the other side of the mould, while not exactly double, will require additional epoxy. Estimate the amounts needed for all the other pours: dorsal (back), ventral (belly) and tail. The dorsal and ventral pours will require only enough epoxy o cover a strip along their seams to join the two halves of the cast together. Record the estimated amounts.



15. Cut two pieces of 19 mm (3/4") plywood or particle board the length and width of the mould or use the top and bottom of the mould box. Measure the location of the eye/pour hole and mark this location on one of the boards. Drill a 50 mm (2") hole through the board at the centre of the mark. Put this board under the back-side half of the mould with its hole over the eye/pour hole in the mould. The eye/pour hole is exposed through the hole in the board.

    Support the view-side half of the mould on the other board with its cavity upwards. Lightly coat the registration keys (See: Roughscale Grenadier —making a two-piece mould, step 5) with Vaseline so they will pop into place easily. Mix the estimated amount of epoxy needed to fill the tail cavity and pour it into the view-side half of the mould. Fit the other half of the mould on top and snap the registration keys securely together. Put the second board on top with the eye/pour hole exposed through its 50 mm (2") hole. The two boards sandwich the mould. Clamp them together with wood clamps, being careful not to over tighten the clamps as that can distort the shape of the mould and cause leakage and an uneven seam line. Stand the mould on end, tail down, with a slight inclination toward the dorsal (back). Leave it for about four hours to cure.

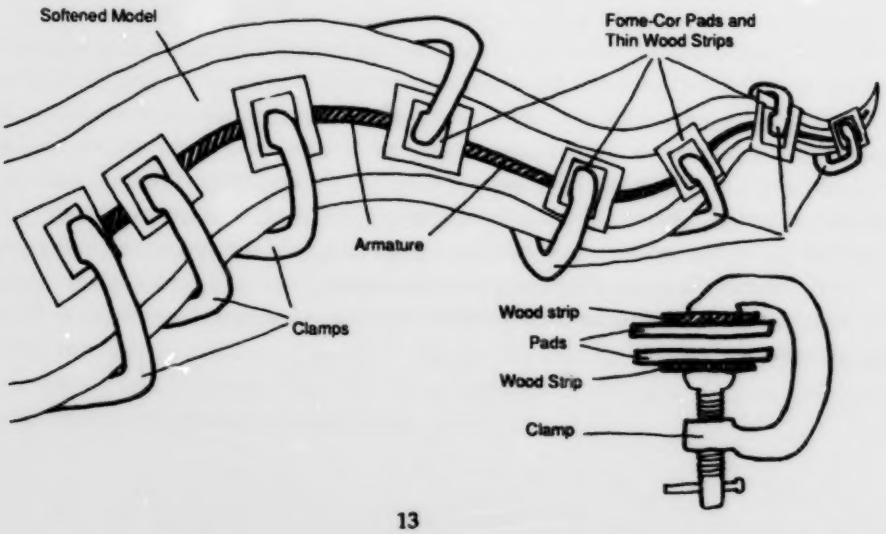
16. Lay the mould, still sandwiched between the boards, with the back-side uppermost. Remove the Sculpy plug from the mould's eye/pour hole. Mix the previously estimated amount of epoxy

needed for the dorsal seam. Pour it into a 60cc syringe (with no needle attached). Inject the epoxy into the mould, through the eye/pour hole, with the syringe. Prop the mould with the dorsal side down so that the epoxy will lie along the seam line while it cures. This will join the two halves of the lay-up together. Let it stand for four hours.

17. Repeat this procedure with the estimated amount of epoxy for the ventral area and prop the mould, belly side down, to join that seam together. Let the epoxy cure for four hours.

18. Fill the head area last and replug the eye hole with uncured Sculpy before propping the mould, head down, for the final cure. Let the epoxy cure thoroughly for at least 12 hours. This will ensure that the epoxy model is hard enough to hold its shape after it is removed from the mould.

19. Remove the mould box, then remove the model from the mould by separating the mould halves. Beginning at the tail end, slowly pull the back-side of the mould off the cast until it is completely freed. Loosen the edges of the view-side of the cast with a dull blade. Peel it away from the cast, beginning again at the tail end. Heating the mould and cast with warm water will make the cast less brittle. Continue to carefully work the view-side of the mould loose and gently pull on the cast until it is freed. Clean off any flashings along its seams. Clean up and shape the fins with a small blade or Dremel tool with a buffer bit. Because drilling or buffing epoxy warms the surface and softens it, scraping with a sharp blade is often a more successful way of smoothing it. A plastic polish can be used for final finishing.



20. One straight sculpture can be reproduced several times. Each cast can then be posed in different attitudes by forming the cast models' tails along implanted steel armatures. This can help to make the models appear more life-like and reduce the number of sculpted models and moulds needed for a diorama. The tail or rear section of the model must be solid epoxy if it is to be shaped by this method.

21. Use a Dremel tool to grind out a tapered groove large enough to install a steel or aluminum rod armature on the back-side of the model. The size of rod will vary according to the size of the model. If the model is to be seen from both sides, the armature must be able to lay in the groove slightly below the surface of the model. The armature can then be completely covered with epoxy and concealed with texture.

22. Clamp a length of steel (or aluminum) rod firmly into a bench vice. Measure exactly the length of the groove in the model. Mark this length on the armature. Do not cut off the armature at this time because the extra length is useful for handling purposes during the bending procedure.

23. Use a heavy belt grinder to taper the armature to fit the groove. Hold the end of the armature firmly in both hands and pull along its length, pressing onto the fixed grinder as you do so. Increase the pressure as you near the tip. This will create a gradual taper in the steel. Continue this until the desired taper has been achieved.

24. Consult with the curator to determine a realistic swimming position. Begin bending the armature by applying gradual pressure or tapping it gently with a hammer until the metal gives. Move the armature along about 50 mm (2") in the clamp, then reclamp and repeat the bending process. Continue this process gradually until the entire length of metal is shaped. It is easy to add more curve once the basic desired shape has been achieved but it is very difficult to unbend kinks or angular curves. Cut off the excess length of armature with a hack saw.

25. Installation of the armature will require assistance from at least one other person. Fill a sink with very hot tap water (wear insulated rubber gloves to protect your hands). Submerge the portion of the tail to be curved and hold it in the water until it becomes flexible. It will take quite a long time for the heat to penetrate through the larger models. Be careful not to apply any stress to the tip of the tail as it will be very flexible almost immediately and therefore, quite fragile.

26. When the thick part of the tail can be flexed by applying pressure, the model is ready for armature installation. Clamp the large end of the armature into place in the model's groove. Protect the model where the clamps press against it with small pieces of wood and Fome-Cor or similar padding materials. While one person pulls the tail over the next few inches of the armature, the other person clamps it into position. Work quickly down the length of the tail (toward the tip) until the armature is completely installed. The model can be resubmerged into the hot water at any time if it becomes inflexible. Stress fissures can be caused by excessive stretching of the surface when the inner epoxy is not sufficiently warm. They are disastrous on the view-side because they can not be repaired. When bending the tail, always work from the view-side of the model so that the surface can be monitored for signs of cracking.

27. In the spaces between the clamps, apply epoxy—colour matched to the model—into the groove to glue the armature into place. Work on a horizontal surface or the epoxy will run off before it cures. The epoxy can be thickened with Aerosil to increase its viscosity and help keep it in place. Cut angel veil fibreglass mat into very small strips. Stuff the fibreglass mat around and over the armature and wet it thoroughly with the epoxy. Allow the epoxy to cure overnight. Remove some of the clamps and repeat the procedure in these newly exposed areas. Note that there is a lot more stress at the thicker base of the tail than at the tip, so be careful not to remove too many clamps at once in that area. Epoxy has what is called "memory", meaning that over time, the model will try to return to the straight position in which it originally cured. If the armature is not sufficiently held in place by the epoxy, it will pop out and the model will gradually lose its curve. The fibreglass mat, applied with maximum surface contact to the armature and model, should ensure that this does not occur.

28. The model is, at this point, a cream colour with black-brown fins. Paint the model with very light coats of oil paint thinned with turpentine or laquer thinner. Allow the paint to dry between coats. Laquer thinner in particular will accelerate the drying time. Use a colour sketch, consultations with the curator, observation of preserved specimens and written descriptions as references for painting.

29. Cast the pectoral fins in their separate one-piece moulds (see Roughscale Grenadier— making a two-piece mould, step 13). Paint an appropriately tinted epoxy layer into the fin moulds being very careful to fill the points of the fin rays and the edges of the membranes. Bubbles will tend to form in these areas. Heat the epoxy with a heat gun and brush it to remove any air bubbles. Each fin can usually be filled within two or three coats. Cure the epoxy between coats. The fins can be placed in an oven to accelerate the curing.

30. When the final layer of epoxy has completely cured, remove the cast fin from its mould. The cast will be much thicker than required for the finished fin so the back of it must be ground down to the proper thickness. The easiest way to accomplish this is to grind with a rough Dremel bit and then hand scrape it to a smooth finish with a scalpel blade. This can take an hour or more to do properly. Be very careful not to press too hard as the epoxy has a tendency to heat up from friction and from handling. It can then stretch under the blade while being scraped. When this happens, fin tips can be easily pulled off. It helps to periodically run the fin under cold water. When the scraping is finished use a Dremel tool with a buffer and some plastic polish to polish the back of the fin. Finish buffing with a soft, dry cloth. This last polishing will make the membrane appear much clearer by filling in the matte texture of the cast.

31. Use a Dremel tool to shape the attachment tabs on the fins and to make small incisions on the model so that the fins can be easily inserted into their final positions. Clean the fins thoroughly as they are too fragile to clean once they are installed. Add a drop of cyanoacryllate glue (such as Locktite Quick Set 404 industrial adhesive) onto the tab. Quickly insert the tab into the slot and hold firmly in place for about 30 seconds while the glue sets. A thickened epoxy can also be used to glue the fins in place. Mix tinted 5-Cure epoxy (A & B parts) with some Aerosil filler and apply the mixture into the cut on the model. Put the rest of this epoxy paste on the fin tab and slide the tab into the cut. Hold it in place until the epoxy cures. This has the advantage of filling any extra space around the tab and the epoxy can be tooled after it has cured.

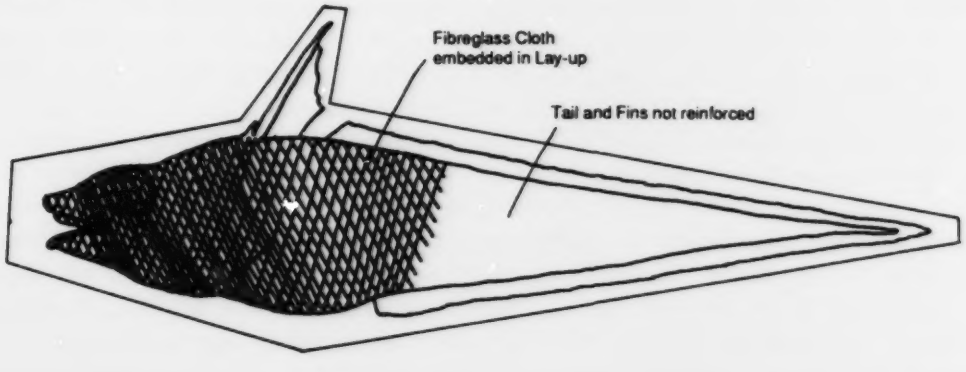
ROUGHSCALE GRENADIER *(Coryphaenoides acrolepsis)*

Casting a solid epoxy model in a two piece mould with multiple colours in the lay-up

(SEE: ROUGHSCALE GRENADIER, page 6)

IMPORTANT: Read Health Hazard Warning—page 10

1. The colour of a real specimen is located not only on its skin's surface but is distributed through its skin's many layers. Great depth of colour is achieved when these layers of colour are viewed, on top of one another, against an opaque base. Lifelike coloration can be attained on a model by imitating this phenomenon when laying up a mould. A series of varying transparent or translucent layers of epoxy are built up. Characteristic patterns can be introduced into some of these layers. When laying up the model, the order of applying the colours and patterns is reversed from the order of normal surface painting. The layer closest to the outer surface is put on first and the furthest from the surface is applied last.



Careful planning is required to achieve the desired effect because the progress of the colouring can not be checked until the cast is taken from the mould. Very little adjustment is possible at that point. Planning the lay-ups can be facilitated by using clear plastic sheets when doing the preliminary colour sketch. Each layer of colour is applied onto a separate plastic sheet. Then the sheets are assembled to see the cumulative effect. Small test patches can be laid up in the mould to ascertain how texture and location on the cast will affect the colours' final appearance. While the mould is being cast, a record sample can be simultaneously created on a clear plastic sheet. This can be turned over and viewed to gauge the progress of the lay-up. Colour and patterns can be introduced into the layers in two ways. The epoxy can be tinted and/or filled and manipulated, or clear epoxy layers can be alternated with layers of acrylic or oil paint or dyes.

2. Spray the mould with Frekote 700 release agent and allow it to dry.

3. Always work in a well ventilated area and wear an approved organic vapour respirator when working with epoxies. Avoid *any* skin contact. Using a colour sketch (approved by the curator) and/or photographs and slides, do a rough multiple colour lay-up with pigmented Nu-clear epoxy

in the view-side of the mould (See: Roughscale Grenadier—Casting a solid epoxy model, single colour, step 5–7, 11). Keep chronologically numbered samples of each colour to be used for reference when doing the final cast. Try to be accurate with the colouring so that this pull will be a valid colour test. There will be 10–15 layers of skin colours before desired saturation and blending is achieved. Back these layers with a flesh-coloured epoxy. This can be clear, untinted epoxy with Aerosil added to give it a milky colour. The Aerosil will also thicken the epoxy and keep it from running off the vertical surfaces and high points in the mould. The lay-up should now be about 6 mm (1/4") wide at its thickest areas. Back this with layers of fibreglass cloth or mat and clear epoxy. This will give strength to the shell. Each layer can be heat accelerated with a heat gun to speed up the process. Nu-Clear epoxy, when heat accelerated, can cure in about half an hour.

4. After the fibreglass layer has cured, carefully remove the cast from the mould. Running warm water over it will help make the cast less brittle but with the fibreglass backing this should not be necessary. Have the curator approve the colour of the test cast and keep it for a reference for the final cast. This first cast should also pull out any bits of the Sculpy original still stuck in the mould. Cover the view-half of the mould and set it aside for future use.

5. If the first test is nowhere near correct in colour, repeat the entire skin colour test procedure in the back-side of the mould, making adjustments where necessary. Keep chronologically numbered samples of these colours to replace the first set. Remove the cast and check the adjusted colour.

6. This second cast should be close enough to the desired finished colour so that, with only fine tuning, a final cast can be done. Both halves of the mould are now cleaned and ready for the final cast. If the first cast is reasonably close to the desired finished colour, proceed to clean the back-half of the mould by laying up a 6 mm (1/4") thickness of untinted epoxy in it. Back it with fibreglass cloth, let it cure and remove it from the mould. Cover the back-side half of the mould and store until needed.

7. When laying up the cast of the exhibit model, apply each epoxy colour to both the view-side and back-side halves of the mould simultaneously so that the colour at the seams will match. Lay up the main body first from gills to the end of the tail. Do not apply epoxy to any of the fin areas. Let the epoxy cure. Next lay up the head area and let it cure. With uncured Sculpy, build a dam inside the view-side body cavity— along the bottom edge of the fins—to prevent epoxy painted into the fins from running back into the body cavity (See: Roughscale Grenadier—Casting a solid epoxy model, single colour, step 3). Mix the pretested colour for the fins. Paint in and cure a few layers of this epoxy until fin areas are completely covered. This is done only in the view-side of the mould. Leave the fins bare on the back-side half of the mould. The fins would be too thick if the fin areas on both halves of the mould were laid-up and then sandwiched when the model is joined together. Apply fibreglass cloth in the head and the main body cavity up to the edges of the fins and up to the base of the tail. Do not fibreglass the fins or the tail area. The tail will be curved at a later step and fibreglass cloth in the tail section will make it too inflexible to be formed.

8. Rub a thin layer of Vaseline over the registration keys so that they will slide together easily. Scrape off any excess epoxy that would interfere with the two halves of the mould fitting together properly. Clean all around the edges of the mould and blow it off with compressed air. Paint a thin layer of Vaseline outside the seam area on the edges of the mould to help seal against seepage. Pour enough untinted epoxy into the open view-half of the mould to completely fill both the tail sections when they are put together (See: Roughscale Grenadier—Casting

a solid epoxy model, single colour, step 14). Work quickly. Snap the two mould halves together. Work them together to make sure they are snugly registered. Sandwich the mould between the top and bottom boards of the mould box with the eye/pour back-side half's hole exposed through a pre-drilled 50 mm (2") hole in the back board (See: Roughscale Grenadier, single colour, step 15). Clamp the boards firmly together. Do not overtighten the clamps or the mould will distort, causing leakage and an uneven seam line. Stand the mould upright on its tail end. Allow four hours to cure.

9. Using a large syringe without a needle, inject through the eye/pour hole enough untinted epoxy into the body cavity to join the two mould halves together along the ventral (stomach) seam. Stand the mould horizontally, stomach side down, to cure for four hours.

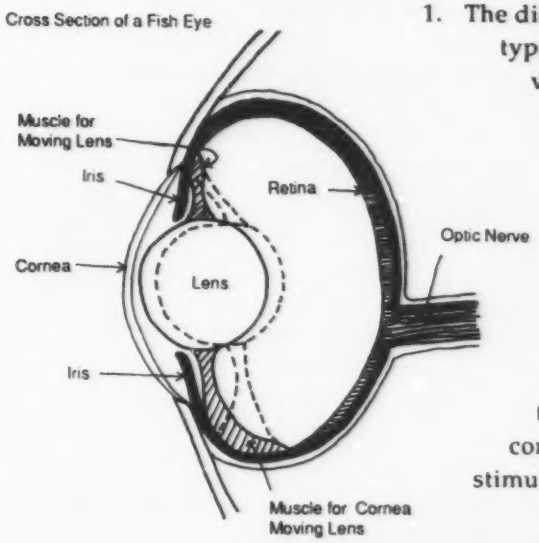
10. Repeat this procedure for the dorsal (back) seam. Tint the epoxy an appropriate colour to match the casts back. Do not allow this back-colour tinted epoxy to run into the head area. Replug the eye/pour hole with Sculpy during the dorsal seam curing.

11. Remove the eye/pour hole plug. Using a large syringe without a needle, inject enough epoxy (tinted to match the lip colour) to solidly fill the head cavity back to the gills. Replug the eye/pour hole. Stand the mould upright on its head. Allow 12 hours for a complete cure. This will ensure that the epoxy model is hard enough to hold its shape after it removed from the mould.

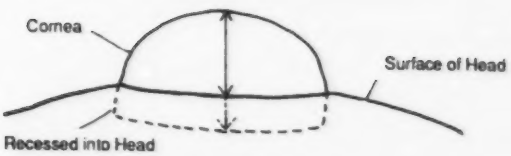
12. Remove the cast from the mould and finish the model. Form the model along an implanted armature, then cast and attach the separated fins (See: Roughscale Grenadier—Casting a solid epoxy model in a two-piece mould, solid colour to be surface painted, step 19–34). Hand paint, wherever necessary, to add surface colour and intensity. Separation between colour layers can be accented with some subtle hand painting. Use oil paints diluted with turpentine . Apply enough paint to colour the surface of the epoxy and then scrub it off with a dry brush, leaving only a slight stain. Be sure to clean all excess paint from the depressions and detail or the painting will look like exaggerated shadows. By having almost no paint on the cast's surface, the texture of the fish will remain as it was when it came out of the mould and will not require any matting or dulling spray.

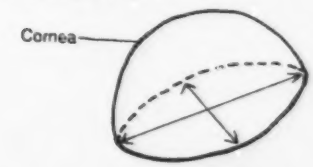
ROUGHSCALE GRENADIER *(Coryphaenoides acrolepsis)*

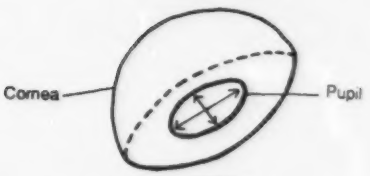
Making Eyes with Lenses



1. The diagram at the right shows a cross-section of a typical fish eye which, unlike the eye of a terrestrial vertebrate, focuses by moving the lens without altering its shape. This movement is carried out by muscles within the eye. The eye has a coloured iris surrounding an opening or window called the pupil. The outer surface of the eye is the cornea. The cornea has no optical function in fish because it has the same refractive index as the water in which the fish swims. Light passes through the cornea, the pupil and the lens before striking the retina, at the back of the eye, which contains the rods and cones which are sensitive to colour and light. The stimuli from these are carried to the brain by the optic nerve.







2. The following information must be known before attempting to make a fish eye from any material. Make the observations from specimens. (Note: The domed surface of the cornea distorts what is seen beneath it, much like a lens, so dimensions must be recorded as they appear rather than as they really are.)

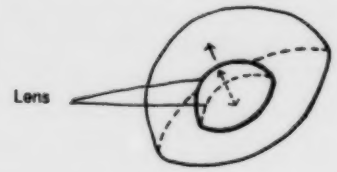
   (a) **The apparent dimensions of the cornea:** Is it one-half or one-third of a sphere? How far does it stick out from the fish's head? What is the diameter of the cornea at the iris level or, if the eyeball is not spherical, what is its length & width at the iris level?

   (b) **The apparent dimensions of the pupil as seen from the front of the eye:** Is it round or egg-shaped?

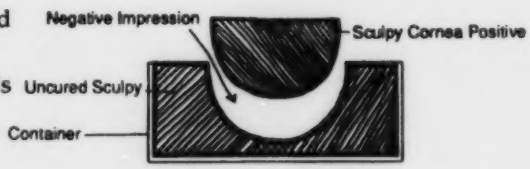
   (c) **The apparent dimensions of the lens at the pupil level:** If it is not obviously different, use the same length and width as for the pupil.

   (d) **The position of the lens within the cornea:** Is it close to the front or is it depressed to the iris level? (NOTE: This position changes with the focus of the eye. See diagram—Making eyes with lenses, step 1)

(e) **The shape of the iris and the lens as seen from the side of the eye (in cross-section):** Is the iris convex or concave and how changeable is its shape? Does it look three dimensional from the side or could the iris/pupil/lens be made flat? Will these details be visible when the model is mounted in the exhibit?

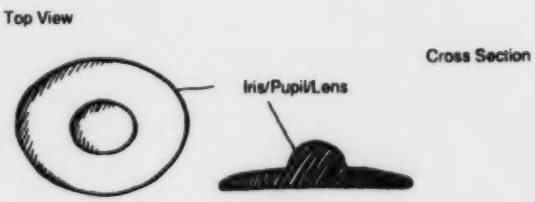


(g) **A detailed colour sketch of the eye as seen from the front:** Using acetate overlays can be helpful (See: Roughscale Grenadier—Casting a solid epoxy model in a two-piece mould, multi-colour in the mould lay-up, step 1). Make thorough written descriptions of translucence, transparency, iridescence and other physical characteristics. Include the immediate head area surrounding the eye because iris and head colours often relate. The way in which the eye appears to be fitted into the socket is also important. When the appearance and dimensions of the eye have been established, and approved by the curator, production of the model eye can begin. The following procedure is for the Roughscale Grenadier's eye.



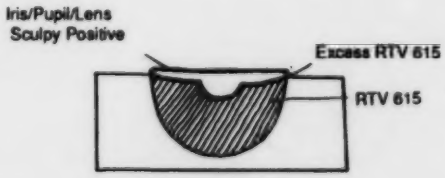
3. Sculpt a positive of the cornea shape in Sculpy. Heat cure it in an oven.

4. Press uncured Sculpy into a small container that is deeper than the height of the Sculpy cornea shape. Level and smooth the top surface of the uncured Sculpy. Wet the cornea positive with water to act as a release agent. Press it into the uncured Sculpy and then remove it. There will be a negative impression in the uncured Sculpy block. Cure the Sculpy block in an oven. This is the cornea mould.



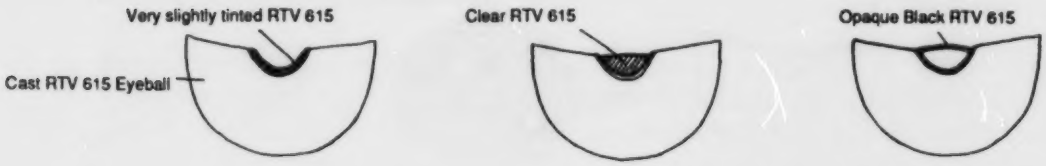
5. Sculpt a positive of the iris/pupil/lens shape in Sculpy. Heat-cure it in an oven.

6. Measure and catalyze enough clear General Electric RTV 615 silicone rubber to fill the cornea mould. Evacuate the air from the RTV 615 in the vacuum chamber. Fill the cornea mould almost but not quite to its top. Carefully place the iris/pupil/lens Sculpy



to its top. Carefully place the iris/pupil/lens Sculpy positive into the RTV 615 and suspend it in the correct position. Be careful not to trap air bubbles between the Sculpy positive and the surface of the RTV 615. Cure the RTV 615 in an oven at 148°C (300°F) for about 15 minutes.

7. Remove the iris/pupil/lens positive from the cured RTV 615 in the cornea mould. Remove the RTV 615 cast eyeball (cornea) from the cornea mould and inspect it before proceeding. If there are no imperfections such as air bubbles in the cast go on to the next step. Slight surface imperfections may



be corrected by coating the entire surface with a thin layer of RTV 615 and then curing it in an oven or with a heat gun. The RTV 615 must be applied thinly and cured quickly or it will run off and drip.

8. Mix a very small amount of black pigment into some RTV 615 and vacuum to remove any air bubbles. A good quality powder pigment or a pigment formulated for PVC plastics can be used. Paint a very thin coat of the very slightly black-tinted (almost clear) RTV 615 into the lens depression. Brush it to make an even coat and then remove all excess RTV 615 to avoid puddling. Cure quickly with a heat gun. This will give the appearance of a lens surface in the eyeball.

9. Fill the remaining pupil depression not quite to the top with clear RTV 615 that has had the air removed. This is the interior of the lens.

10. Mix some RTV 615 with enough black pigment to make it opaque and vacuum it to remove the air. Paint a thin coat of this RTV 615 into the back of the pupil depression but still do not fill it quite to the top around its edges. This will opaque the back of the lens and represent the pupil.

11. Most fish have a well-defined ring of colour, often iridescent, immediately adjacent to the pupil. Mix a small amount of RTV 615 and tint it the appropriate colour—iridescent powder pigments are available—and evacuate the air from it in the vacuum chamber. Fill the rest of the pupil depression with this tinted RTV 615. Use a fine brush to extend the tinted RTV 615 outside the depression to form a thin ring colour around the pupil. Use a heat gun to keep the eyeball hot during this procedure so that the RTV 615 will cure quickly before it has a chance to flow out of the desired position. Paint on a thin flesh-coloured ring of RTV 615 around the outer edge of the eyeball.

12. Mix more RTV, tint it the various hues of the iris using colours worked out on the colour sketch and paint it onto the iris area. Apply the RTV 615 with a small brush onto a heated eyeball to achieve the correct mottling or blending of colours. Build up the colours and patterns in thin, translucent layers.

13. Fill the entire back of the eyeball with an opaque layer of flesh-coloured RTV 615.

14. Install the eye into its socket on the cast model and touch up the area where the join is made. A careful study of the real thing will aid in creating a convincing eyeball installation. The Roughscale Grenadier and many other species have a fleshy, membrane layer which sheaths the perimeter of the eyeball almost like a thin eyelid. Carefully paint on a ring of pigmented RTV 615 and cure immediately with a heat gun. This layer is very thin so the RTV 615 must be quite heavily pigmented so that it is almost opaque. This layer often has the same colouration as the head area surrounding the eye.

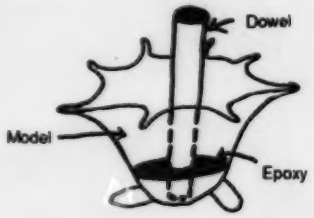
15. Paint on a final clear RTV 615 layer over the entire eye and heat cure with a heat gun.

FLAPJACK DEVILFISH *(Opisthoteuthis california)*

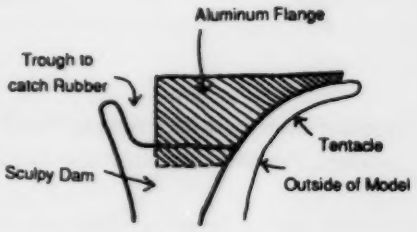
Making a Small Glove Mould
Method One: Freeform Mould

1. A glove mould is built up in layers, using a mould-making material to form a thin skin over the surface of the object to be duplicated. This type of mould requires less mould-making material. The resulting mould is quite floppy and flexible so a second rigid outer shell or "jacket" is built up over the mould layer. The glove mould is encased in this jacket during casting, to support the mould in its correct shape.

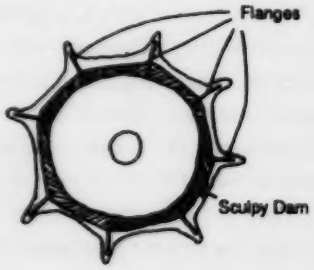
2. Remove the fin flaps with a scalpel. Make separate two-piece moulds of them (See: Roughscale Grenadier—Making a two piece mould). Support the Sculpy model upside down being very careful not to damage its outer surface. A plastic bag partially filled with Styrofoam beads is a good support. Cut a 25 mm (1") diameter wooden dowel to a length that is 50 mm (2") longer than the depth of the model's inside cavity. Pour a pool of Nu-clear epoxy into the inside of the model. Embed the dowel, which will be the armature, by setting it into the pool of epoxy. Support the armature, perpendicular to the model, until the epoxy cures. The dowel will protrude from the model by 50 mm (2").



3. Make a Sculpy dam along the model's bottom edge (tentacle edge) inside the model. Leave the inside of the tentacles and about 6 mm(1/4 ") down from the edge of the model's inner surface exposed. Sculpt the dam to form a trough that will catch and hold silicone rubber. This rubber will form a lip inside the lower edge of the model. Cut flanges from litho-aluminum (very thin metal printing sheets) to fit into the spaces between the inside of the tentacle tips and the Sculpy dam. Install these flanges by pressing them into the uncured Sculpy - perpendicular to the tentacle tips (See diagram). These form very thin part lines in the finished mould that make it easier to release the cast tentacles from the mould.



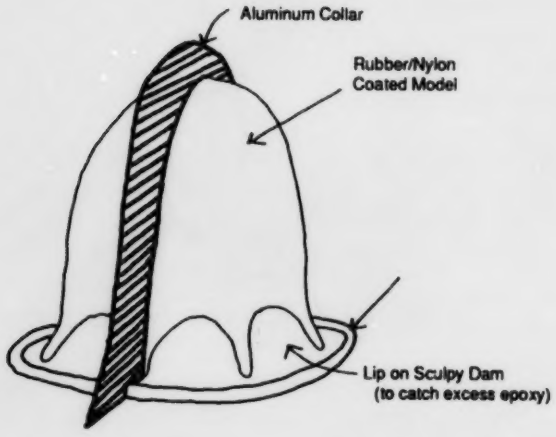
4. Mix "E" RTV Silastic silicone rubber and vacuum it to remove air bubbles (See: Deep Sea Skate, step 6–8). Support the model upside down. Carefully pour some of the rubber over the tentacles and along the inner edge of the model and into the trough formed by the Sculpy dam. Observe any areas that will be undercuts on the out-side of the model when model the is right side up. Dribble rubber over these areas and use compressed air, set at a *gentle* pressure, to force the rubber into deep creases and



undercuts. Cut up nylon stocking into 25 mm (1") squares. Cover the uncured rubber on the inside of the model with the nylon pieces and press them into the wet rubber. Extend the nylon pieces slightly beyond the model's outer edge. Cover the nylon layer with a second layer of silicone rubber. Gently break any bubbles on the rubber's surface with compressed air. Let the rubber cure.

5. Turn the model right side up and support it by its dowel armature. Mix and remove the air from more silicone rubber. Very slowly dribble the rubber over model, starting from the top, and spread it gently with a brush. Let it flow down and drip off. Gently break any air bubbles with compressed air. Make as thin a coating of rubber as possible so that any air bubbles that may be trapped on the model's surface will be able to escape. Let the rubber cure.

6. Mix more silicone rubber and its catalyst together thoroughly and then fold in Aerosil filler to make a sloppy-paste consistency. The Aerosil makes the rubber more viscous so that thicker layers can be built up more quickly on the mould. Remove the air from this mixture in the vacuum chamber. Coat the first rubber layer with this thickened rubber. Cover this layer with squares of nylon stocking and pat their mesh into the uncured rubber. Cover the nylon layer with more filled rubber. Let these layers cure. The curing time can be accelerated by heating the rubber with a heat gun. Apply another rubber/nylon/rubber layer and let it cure. Cheesecloth could be used instead of nylon if a mould does not need to be stretched to release its cast model but this reduces the mold's strength and flexibility considerably.



7. Clean off any rough areas on the cured rubber's surface with a scalpel blade. Coat the mould again, with filled rubber, to make a smooth surface. Pay extra attention to making sure that the bottom edge of the model is completely coated.

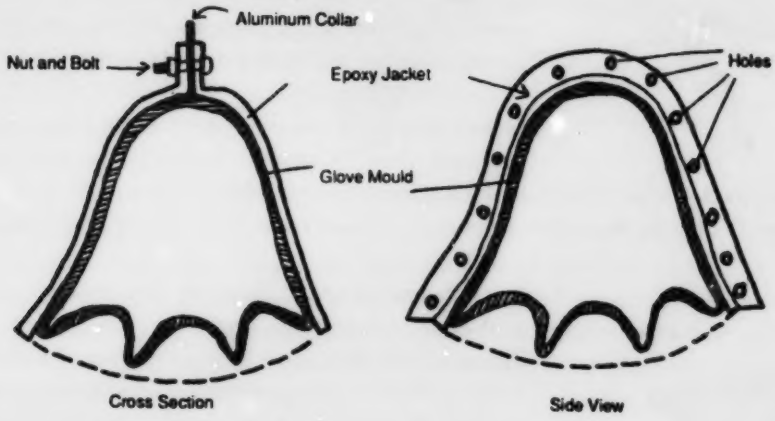
8. A rigid "jacket" must be made to hold the glove mould in its correct shape during casting. Draw a line running over the surface of the mould from the bottom edge of one side, up over the top of the mould and back down the opposite side to the bottom edge. This line bisects the mould into two halves. Create a template pattern of this contour bisection of the mould. Transfer the line's shape to a piece of litho aluminum and cut out a strip, about 75 mm (2–1/2") wide, with the line's shape as its base. Attach the metal to the model with Sculpy. This forms a "break" that will divide the epoxy jacket into two separate halves when the epoxy and fibreglass cloth are laid up over the litho-aluminum.. The break sticks out perpendicular to the mold's surface. Coat both sides of the metal with toluene/Vaseline release agent (See: Roughscale Grenadier—Making a two-piece mould, step 9). Dam between the tentacles with Sculpy and make a lip around the bottom to catch excess epoxy during the jacket construction.

9. Mix Nu-clear epoxy and fill it with Aerosil to a sloppy paste consistency. Coat the rubber mould with

the epoxy mixture. Carry the epoxy up over both sides of the litho-aluminum break to form two collars. Cover over the Sculpy dams between the tentacles down to the lip. Let the epoxy cure.

10. Mix more epoxy and Aerosil filler and coat the jacket again. Press 25 mm by 50 mm (1" by 2") strips of 10 oz. fibreglass cloth into the wet epoxy. Heat the epoxy/fibreglass layer with a heat gun and work the epoxy through the fibreglass cloth, removing any air pockets that are trapped under the cloth. Let the epoxy cure. Repeat this process once more.

11. Drill holes through the epoxy/fibreglass collars and the aluminum break, about every 75 mm (3"), so that the two halves of the jacket can be bolted together.



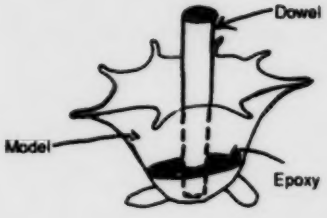
12. Separate the two halves of the jacket and remove and discard the piece of litho-aluminum. Remove the Sculpy damming from between the tentacles and from around the bottom of the jacket.

13. Remove the Sculpy model from the mould. Clean the mould thoroughly. Reassemble the epoxy jacket around the mould and fasten the jacket together with bolts through the holes in the collar.

FLAPJACK DEVILFISH *(Opisthoteuthis california)*

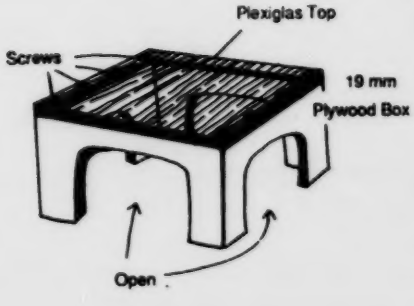
Making a Small Glove Mould
Method Two: Poured Mould

(See: Flapjack Devilfish —Making a small glove mould, step 1)

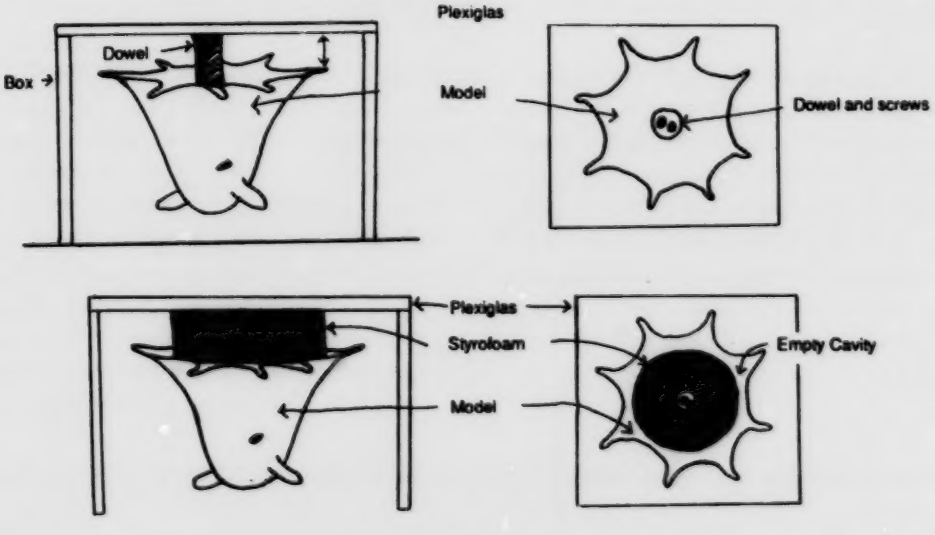


1. Support the Sculpy model upside down, being very careful not to damage its outer surface. Cut a 25 mm (1") diameter wooden dowel to a length that is 50 mm (2") longer than the depth of the model's inside cavity. Pour a pool of Nu-clear epoxy into the inside of the model. Embed the dowel, which will be an armature, by setting it into the pool of epoxy. Support the armature perpendicular to the model until the epoxy cures. The dowel will protrude from the model by 50 mm (2").

2. Make a four-sided box (no bottom or top), from 19 mm (3/4") plywood, about 50 mm (2") higher and wider than the diameter of the Sculpy model. Cut arches out of the sides to make a table-like structure. Make a clear Plexiglas top. Drill holes through it around its perimeter and attach it to the box with screws.

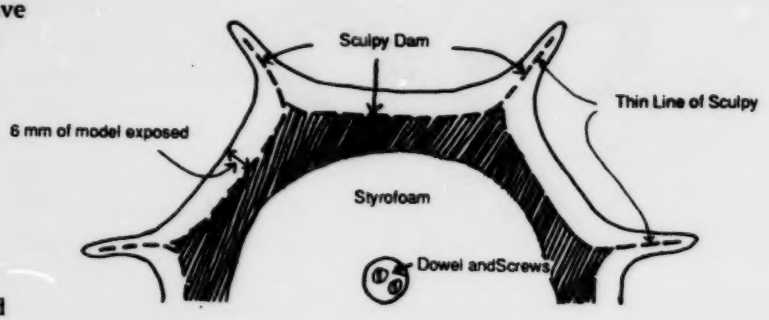


3. Hang the model upside down by the armature. Centre the model in the box, upside down, under the Plexiglas top. Cut the armature to a length that leaves a space of about 25 mm (1") between the tentacles and the Plexiglas. Drill *two* holes down through the Plexiglas, into the end of the dowel. Use two *different sizes* of holes and screws so that the model can be attached in only one position. This will act as registration when the model is detached and reattached. Attach the dowel to the underside of the Plexiglas with *two* screws (through the holes in the Plexiglas and into the dowel).



4. Detach the model from the Plexiglas by removing the screws from the dowel. Carefully support the model upside down. Sculpt and fit a Styrofoam block (with a hole through its centre to fit over the dowel) to fill most of the inside cavity of the model. Make the block deep enough to extend out to the level of the Plexiglas top.

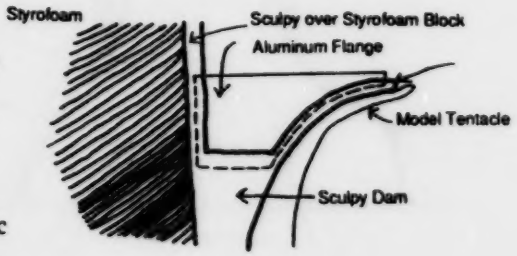
5. Fill the space between the Styrofoam block and the model with an uncured Sculpy dam. Leave about 6 mm (1/4") of the model exposed along its outer edge. Run a thin line of Sculpy almost out to the tips of the tentacles (See diagram).



6. Apply a thin coating of Sculpy over the exposed sides of the Styrofoam block up to the Plexiglas level. Cut flanges from litho-aluminum (very thin metal printing sheets) to fit into the space between the inside of the tentacle tips, the Sculpy dam and the coated Styrofoam block. Insert these flanges by pressing them into the uncured Sculpy perpendicular to the tentacle tips. These form very thin part lines in the finished mould that make it easier to release the cast tentacles from the mould.

7. Reattach the armature to the Plexiglas with the two screws. Turn the box over and use a modelling tool to seal the Sculpy dam (on the Styrofoam block) to the Plexiglas (now at the box bottom).

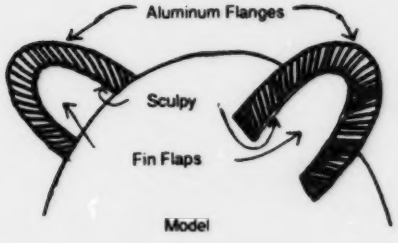
8. Place a piece of litho-aluminum behind the ear-like fin flaps and trace the outline of each onto the metal. Cut out flanges from the metal, about 6 mm (1/4") wider than the outlines, and attach them around their fin flaps with uncured Sculpy. These will form very thin part lines in the mould that will assist in the removal of the model from the mould.



9. Cover the model with a "Stretch and Seal" type of plastic wrap. This prevents the wax used in the next step from sticking to the model.

10. Warm sheets of dental wax to a malleable softness on an electric grill. A thin layer of water on the grill will keep the wax from sticking to the surface. Drape the softened wax sheets over the model's surface. Extend the wax all the way down to the Plexiglas. Build up successive layers to about 6mm (1/4") of wax all over the model. When covering the fin flaps with wax, fill in the space between the body and the flaps (undercuts) with wax so that the mould can be removed from its epoxy "jacket" (the construction and purpose of the jacket will be explained in the next step). If this space is not

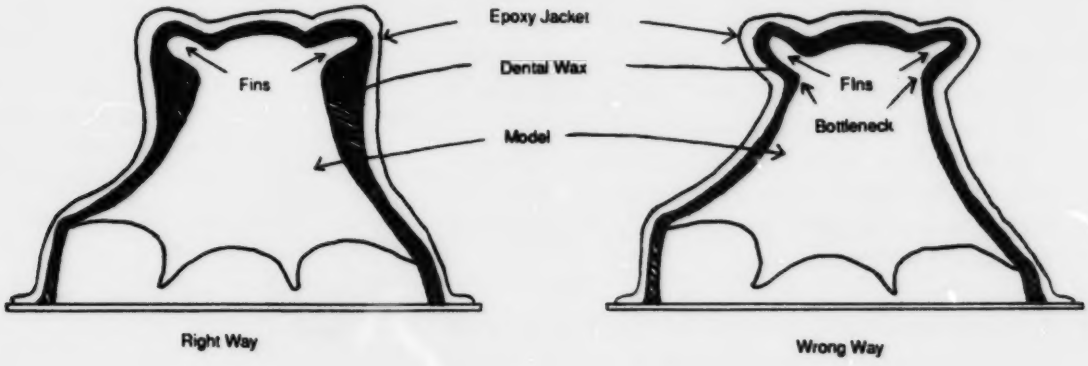
filled in, the jacket will curve under the flaps and a "bottleneck" will be formed which the flaps will not be able to pull through.



11. A "jacket" is now built up over the wax layer using epoxy and fibreglass cloth. This will hold the flexible glove mould in the correct shape during casting. To prevent the epoxy from seeping under the wax layer, seal the bottom edge of the wax to the Plexiglas with uncured Sculpy. Spray the Plexiglas with two coats of Frekote 700 release agent to keep the epoxy from adhering to it.

12. Draw a line running over the surface of the wax layer - from the Plexiglas at the bottom edge of one side - up over the top of the dome - back down the other side to the Plexiglas at the opposite bottom edge. This line bisects the mould into two halves. Create a template pattern of this shape. Transfer the line's shape to a piece of litho-aluminum and cut out a strip, about 38 mm (1 -1/2") wide, with the line's shape as its base. Embed the litho aluminum into the wax layer - bisecting the model from Plexiglas to Plexiglas over the top. This forms a "break" that will divide the epoxy jacket into two separate halves when the epoxy and fibreglass cloth are laid up over the litho aluminum. The break sticks out perpendicular to the wax's surface.

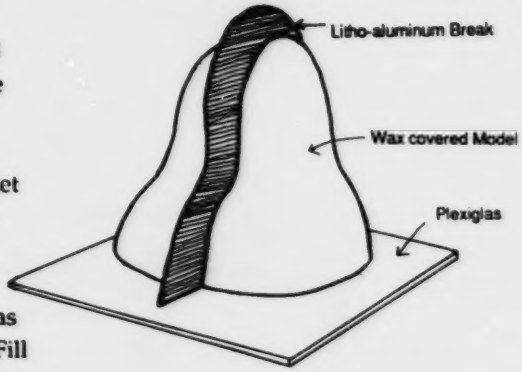
13. Cover the wax layer with a "Stretch and Seal" type plastic wrap to form a release layer.



14. Mix Nu-Clear epoxy with enough Aerosil to form a medium-thick paste that will not readily flow off the wax's surface. Cover the wax with a layer of the Aerosil-filled epoxy. Embed 10 oz fibreglass cloth strips into the uncured epoxy to add strength to the jacket. Cover the cloth layer with more of the epoxy mix and let it cure. Build up several layers of epoxy and fibreglass. Carry the epoxy out onto the litho-aluminum break to form two collars on the jacket perpendicular to the model. These collars make it possible to fasten the two halves of the jacket together. Extend the epoxy layers

horizontally onto the Plexiglas for about 50 mm (2"). This will make it possible to attach the jacket to the Plexiglas.

15. After the epoxy has cured, drill holes about every 75 mm (3") through the epoxy/fibreglass collar and the aluminum break. Drill more holes through the epoxy/fibreglass and the Plexiglas where the jacket overlaps. Fit the holes with nuts and bolts. The jacket can be taken apart and fastened together with these bolts.

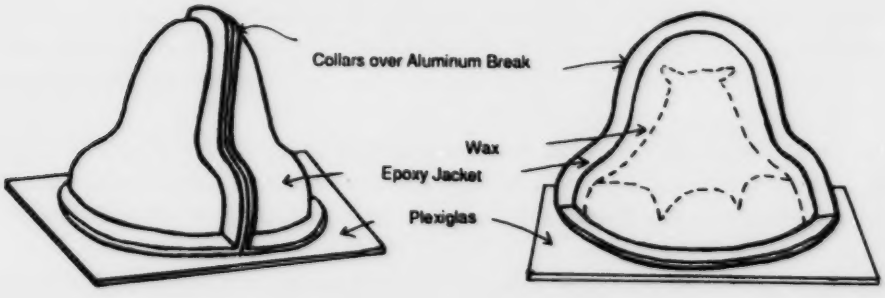


16. Dismantle the jacket from the model and the Plexiglas and remove and discard the litho-aluminum break. Fill any imperfections on the inside of the jacket (such as air holes) with uncured Sculpy. This is done so that when the molding rubber is poured at a later stage, the jacket and mould surfaces will be smooth and snug fitting.

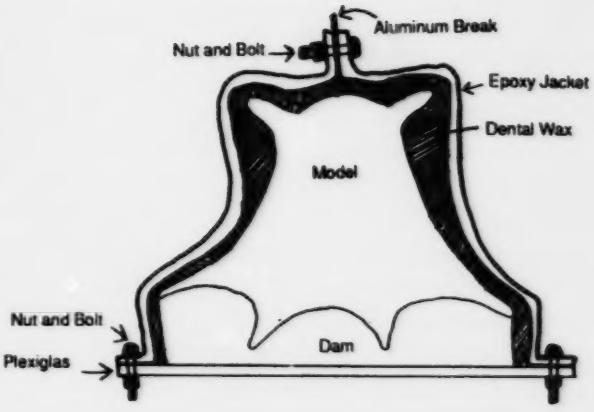
17. Mark with a felt pen where the two edges of the wax touch on the Plexiglas. Carefully remove the wax from the model. Remove the plastic wrap.

18. Coat the inside of the jacket with toluene/Vaseline release agent (See: Roughscale Grenadier—Making a two-piece mould, step 9).

20. Drill several pour holes in the Plexiglas between the felt pen lines (that indicate where the wax used to be located).



21. Put the two halves of the jacket back together and join them with nuts and bolts. Attach the jacket to the Plexiglas with nuts and bolts. There is now a cavity around the model where the wax used to be located.



22. Mix and remove the air from Silastic "E" RTV silicone rubber (See: Deep Sea Skate—Making a one piece mould, step 6–9). Turn the box/Plexiglas "table" over (Plexiglas side up) and pour the rubber into the cavity (where the wax used to be) through the pour holes in the Plexiglas. Let the rubber cure thoroughly.

23. Remove the jacket and dismantle the model and its armature from the Plexiglas. Take out the Sculpy and Styrofoam dam out of the inside of the model and carefully remove the mould from the model. Thoroughly clean the mould.

24. Reassemble the jacket around the mould.

FLAPJACK DEVILFISH *(Opisthoteuthis california)*

Casting a Small Hollow Epoxy Model

(SEE: ROUGHSCALE GRENADIER —page 16)

IMPORTANT: Read Health Hazards Warning
(See Roughscale Grenadier—page 10)

1. Use pigments to tint the epoxy - either a high quality powder pigment (mixed into some of the epoxy resin (A) side as a carrier) or a pigment paste especially formulated for epoxies (such as QCM's EPR series). Pre-mix about 5-10 ml of pigment for each colour so that the tinted batches will be consistent throughout the lay-ups. To check a colour, mix the pigments into a small amount of the (A) side of Nu-clear epoxy and then brush some of the mixture onto a sheet of white paper. Small amounts of the pigment mixtures will be added to each batch of epoxy. Translucency varies with the percentage of pigment to epoxy.

2. Encase the glove mould in its jacket to support it during the epoxy lay-ups. Mix about 10 ml of Nu-Clear epoxy (A & B sides in equal amounts) in a graduated plastic pill cup. Avoid waxed cups because the wax may inhibit the curing of the epoxy. Add a very small percentage of colour #1 pigment to the epoxy. Heat the epoxy with a heat gun to release air bubbles and make it very runny.

   Fill a 3cc syringe (grind off the sharp tip of the needle to avoid damaging the mould) and inject the epoxy into one of the fin flaps. Tip the mould so that the epoxy won't run out when the fin flap is full. Fill the down-side tentacles with the syringe. Dribble the remaining epoxy all over the inside of the mould and spread it around with a brush, heating and reheating it with the heat gun, and distributing it evenly in a beading pattern over and over again. Apply a heavier concentration of epoxy around and along the mould's outer edge.

   Continue heating and distributing the epoxy until it reaches the "toffee" stage (when epoxy no longer thins when heated). To complete the epoxy cure, put the mould in the oven at about 68°C (135°F) for about an hour or leave the mould at room temperature for about six hours. It is important for each layer of epoxy to be completely cured because if it is not complete, the preceding layer may lift off when you heat the next layer.

3. Repeat Step 2, filling the other fin flap. Syringe epoxy into the down-side tentacles and work more epoxy into the edges. Feather texture away from the outer edges and from the fin flaps to blend the solid colour areas into the textured area. Cure the epoxy thoroughly in the oven between layers.

4. Mix 10 ml of #1 colour in a pill cup and heat with a heat gun. Again use the syringe to fill the remaining tentacles and the outer edge. Spread a broken texture all over the mould, feathering away from the fin flaps and edges while heating.

5. Mix 10 ml of very translucent colour #2 and spread over the #1 coloured texture layers avoiding the outer edge. Cure the epoxy in the oven.

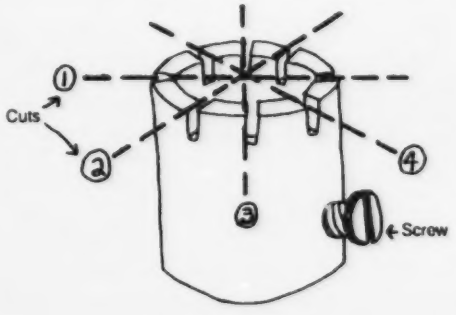
6. Mix a more strongly pigmented colour #2. Heat it and spread it all over the mould until it starts to cure in a mottled pattern. Cure it in the oven.

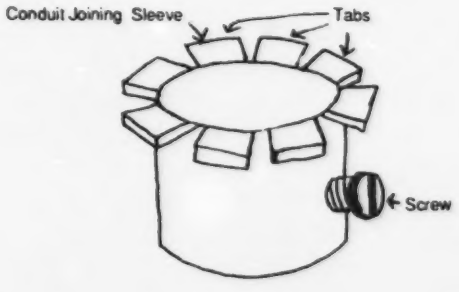
7. Mix about 20 ml colour #1 tinted epoxy and spread it all over the inside of the mould. Work the epoxy into the outer edges and cure it in the oven.

8. Using a dental mirror, check along the inside of the edge for any non-covered areas. Mix a small amount of colour #l epoxy and touch up these spots. Cure the epoxy.

9. Mix about 40 ml of epoxy and colour #3 pigment. Thicken the epoxy with Aerosil filler to a runny paste consistency. Dribble this mixture onto the bottom and sides of the mould and spread it around with a brush.
   Cover the wet epoxy with a layer of bridal veil fibreglass mat. Use a brush to pat the fibreglass mat into the epoxy. Cover the mat layer with more epoxy and work it in. Build up more fibreglass over the fin flap areas for extra strength.

10. Use a hacksaw to cut across the end of a 25 mm (1") diameter electrical conduit joining sleeve. Make four cuts about 6mm (1/4") inch deep. Bend out the resulting tabs. Mix more #3 coloured and Aerosil-filled epoxy and pour it into the mould. Place the conduit joining sleeve with the tabs-end down in the center of this uncured epoxy at the bottom of the laid up mould. Avoid getting epoxy on the screw on the side of the conduit joining sleeve. Heat and cure the epoxy.





11. Mix another 40 ml of epoxy with #3 colour pigments and much more Aerosil to make a thick heavy paste. Apply this mixture over the inside of the mould, spreading and heating it. Lay small 50 mm (2") squares of 10 oz fibreglass cloth over the epoxy covering the conduit tabs. Spread more epoxy on top of the fibreglass cloth and work it into the cloth while heating it with a heat gun. The fibreglass will strengthen the bond. Pour in the rest of the epoxy mix, spreading it all over inside of the mould and up to the edges and heating it as you worked. Cure the epoxy in the oven.

12. Place a 25 cm (10") long piece of conduit pipe into the conduit joining sleeve and tighten the screw on the side of the sleeve with pliers. This forms an strong armature that can be used to help pull the model out of the mould. The conduit joining sleeve can also be used to attach a mount to the finished model for installation in an exhibit.

13. Remove the jacket from the mould. Work along the edges of the mould to loosen the cast model. Roll the mould back and pop out the tentacles. Continue rolling the mould back and ease out one fin flap (POP!). This is a three person job! Slide the rest of the mould from the model.

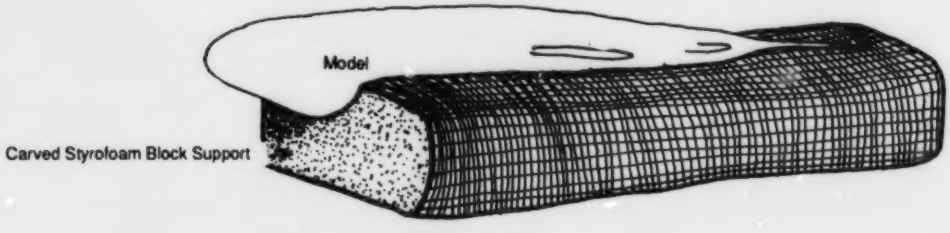
14. When laying up the freeform glove mould (of a model from which the fin flaps had been removed) use the same procedures but lay up the separate fin flap moulds simultaneously (for colour matching). Remove the cast model and the cast fin flaps from the mould. Mix a small amount of #1 colour pigment, 5-minute epoxy and Aerosil filler. Use this mixture to attach the fin flaps to the model. Attach them one at a time. After the epoxy is completely cured, scrape and polish the joins to make them disappear (See: Roughscale Grenadier— Casting a solid epoxy model in a two-piece mould—solid colour to be surface painted, step 19, 30–32).

BLUE SHARK *(Prionace glauca)*

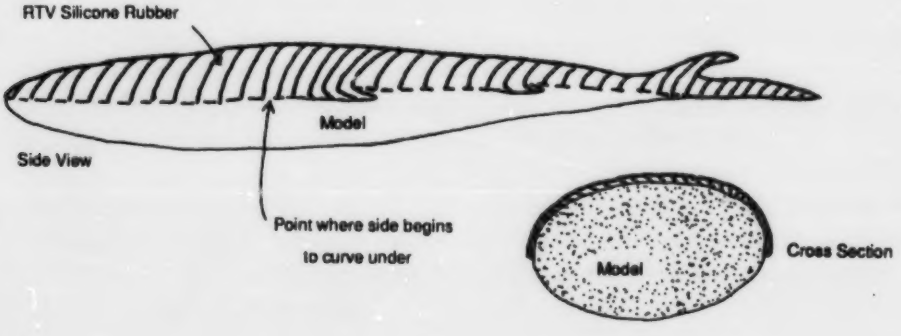
Making a Large Glove Mould

1. (See: Flapjack Devilfish —Making a small glove mould, page 23)

2. The two Blue Shark models are 152 cm and 183 cm (5′ and 6′) long and approximately 55 cm (22″) in circumference. The large size presents some problems in mould making, casting and exhibition mounting. A two-piece mould of such a large model would be very heavy and awkward to make and to cast. It would also take a very large volume of expensive RTV silicone rubber to produce. A glove mould takes less rubber and is easier to handle. To facilitate mounting, the cast epoxy model needs to be as lightweight as possible. Therefore it needs to be thin-walled but also strong enough that the epoxy model's shape will not collapse or distort over time. To prevent this distortion, a lightweight skeletal structure can be built into the model during casting.



3. The mould maker must determine where the sight lines will be located on the model when it is exhibited. It is quite awkward to hold a large model in position while these sight lines are being ascertained, so it is more convenient to establish them using a smaller, scale model. The seams and openings of the mould will be located beyond the sight-lines where they will not be visible to the viewer. The sight lines of this model allow this mould to have an opening on the side away from the viewer.



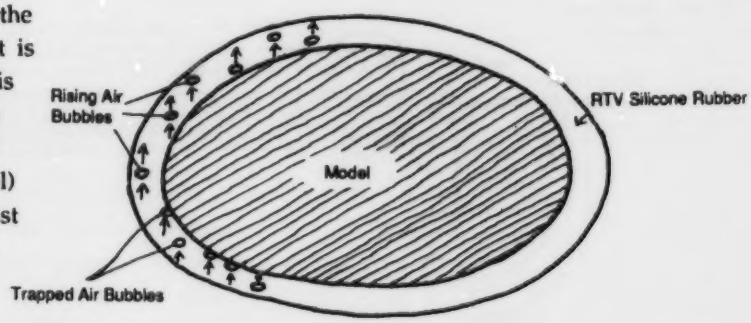
The casting lay-ups will be done through this opening so it needs to be as large as possible without being visible on the view-side of the completed model. A large opening also reduces the weight of the cast model. After the location of the back-side opening has been located on the scale model, the opening can be drawn directly onto the full-sized model.

4. Remove the pectoral and anal fins. They will be made separately and installed during the finishing stage.

5. Carve Styrofoam blocks to form a secure support for the Sculpy sculpture. Lay the sculpture on the Styrofoam block horizontally, with the side that will be viewed when the model is exhibited facing up.

6. Brush a very thin coat of RTV Silastic "J" silicone rubber onto the view-side of the Sculpy model. Coat only down to the point where the side of the model begins to curve back under the view-side.

   Thin a small amount of the rubber with Dow Corning 200 dielectric fluid. Use a small brush to work this less viscous rubber into deep crevices, such as the gills and nostrils. Gently blow compressed air, set at very low (3–10 psi) pressure, over the surface of the rubber to release any air bubbles. Take care not to force air *into* the rubber. Let this coating cure at room temperature for about twelve hours. Curing slowly this way allows any air bubbles still in the rubber to migrate away from the model's surface before the rubber sets. Since air bubbles rise, that is why only the upper half of the model is coated. If the rubber is coated onto an undercut (such as the area that curves back under the view-side on the model) the bubbles can become trapped against the model's underside surface as they migrate upwards.

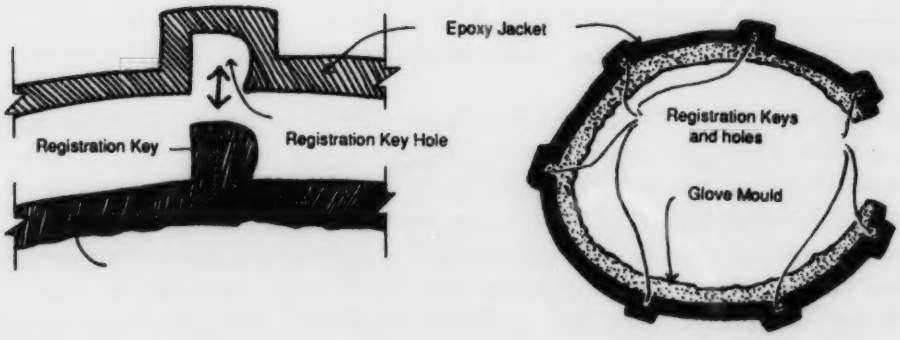


7. Turn the model over and repeat the procedure on the other half. Leave the opening on the back-side (as worked out on the scale model) uncoated.

8. Cut nylon stocking into 50–150 mm (2"–6") square pieces. Thicken silicone rubber with Aerosil filler (See: Flapjack Devilfish , Making a small glove mould , Method two, step 7). The first layer of cured rubber is covered with a layer of filled rubber reinforced with the nylon mesh. Lay the squares of nylon out so that they completely cover the mold's surface with edges touching or overlapping each other. Hold each square in position by tacking one edge to the mold's cured rubber surface. This is done by dabbing some of the filled rubber onto one edge of the square and curing it with a heat gun. Perform the tacking procedure on each piece of nylon. Tacking the nylon keeps it from sliding out of position on the wet rubber. After they are all secured in position, lift each piece of nylon and completely cover the mould surface under it with the filled rubber mixture. Pat the nylon back down into the uncured rubber, squeezing it up through the mesh. Coat more rubber onto the top of the nylon. If rubber is applied only to the top surface of the nylon, air pockets can be trapped between the rubber/nylon layers . These air pockets weaken the mould's skin.

9. The glove mould is quite flexible. When spanning over a large expanse, it will need to be attached to a rigid jacket to keep it from slumping out of shape on overhangs.

By manufacturing protrusions and attaching them to the outside of the mould, registration keys are created. When the epoxy jacket is laid-up over them, registration key holes are formed in the jacket. The registration keys can be popped into their key holes when the jacket is put onto the mould. They can be pulled out of the key holes again when the jacket needs to be removed from the mould. These registration keys will hold the thin rubber glove mould in its proper position against the jacket during casting.



10. Use the following procedure to make a mould of the registration key shape. Use this to manufacture the protrusions that will be attached to the outside of the mould.

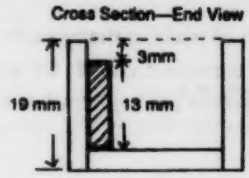
    (a) Cut three 19 mm (3/4") wide by 13 mm (1/2") long strips of Fome-Cor. Butt join the sides, overlapping the bottom. Cut two 19 mm (3/4") square pieces of Fome-Cor and butt join them over the ends, overlapping the sides and bottom. Tape the sides, bottom and ends together. Cover the seams on the outside with masking tape.

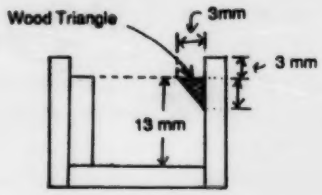
    (b) Cut one 13 mm (1/2") square strip of Fomecor and glue it upright onto one side of the mould box interior.

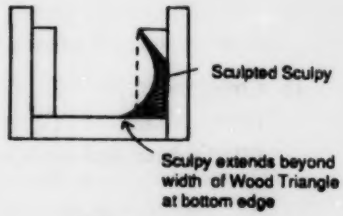
    (c) Cut a 3mm (1/8') wooden triangular wedge 13 mm (1/2") long and glue it to the inside of the box -on the side opposite from the 13 mm (1/2") strip of Fomecor - as shown in the diagram below.

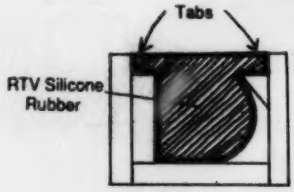
    (d) Fill in the area under this wedge with Sculpy and sculpt a curve into the Sculpy's exposed surface as shown in the diagram below. When the mould has been cast, the resulting registration key will have a curved side that will hold the key in place in its corresponding jacket hole, even when the mould is suspended on overhangs.

11. Fill the mould with RTV Silastic "J" silicone rubber to the top of the box. Tabs are formed when the 3mm (1/8") space above the strips of Fome-Cor, wood and Sculpy is filled with rubber. These tabs are the base of the registration key and facilitate attachment of the key to the mould. Let the rubber cure. Remove the cast registration key from the mould.

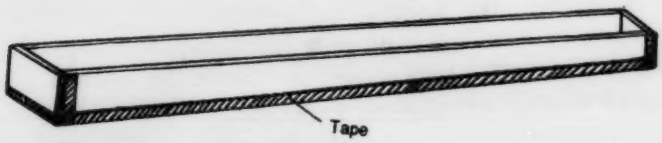


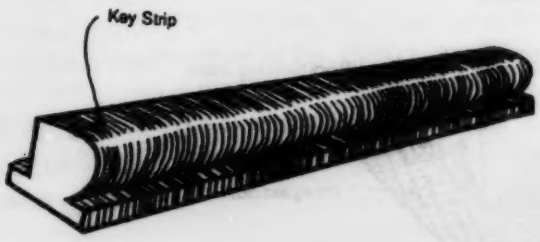




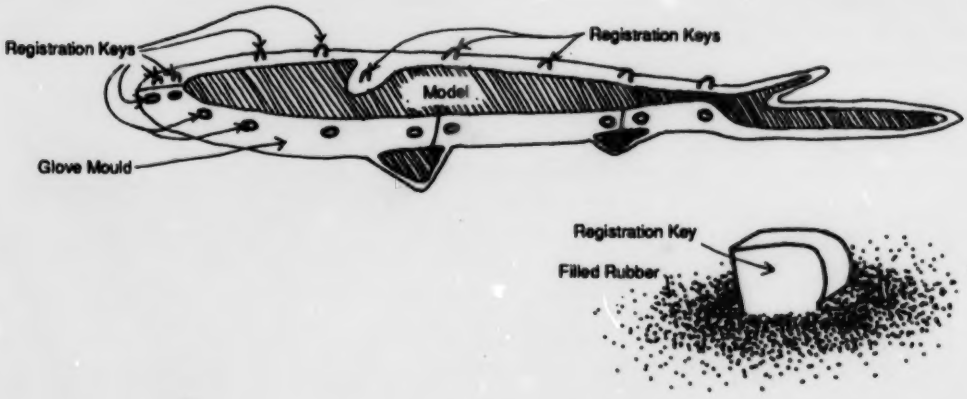


Finished Registration Key

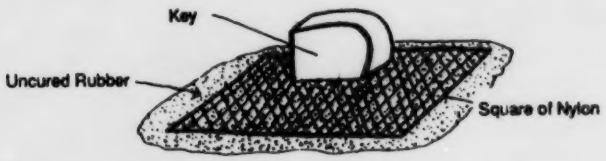


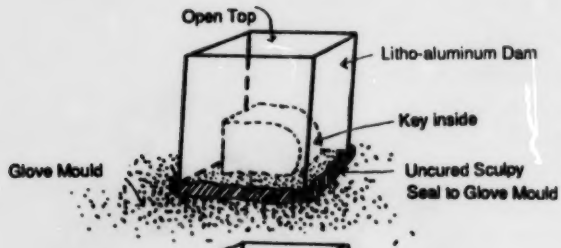


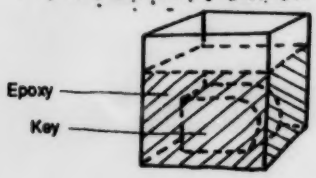
12. Instead of making many casts of the single registration key mould, a long mould about 1 m (3') long can be constructed and cast with rubber. The resulting strip can be cut into 13 mm (1/2") sections. Each section is a registration key.

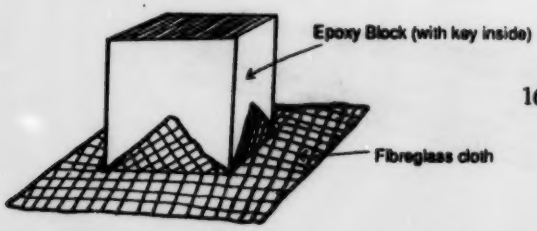


13. Cover the upper side of the glove mould with a third layer of filled rubber over the nylon/rubber layer. Attach the cast registration keys where needed (edges, seams, top of curves etc.) using more filled rubber and use a heat gun to cure each key in place. Cure the rest of the rubber layer.









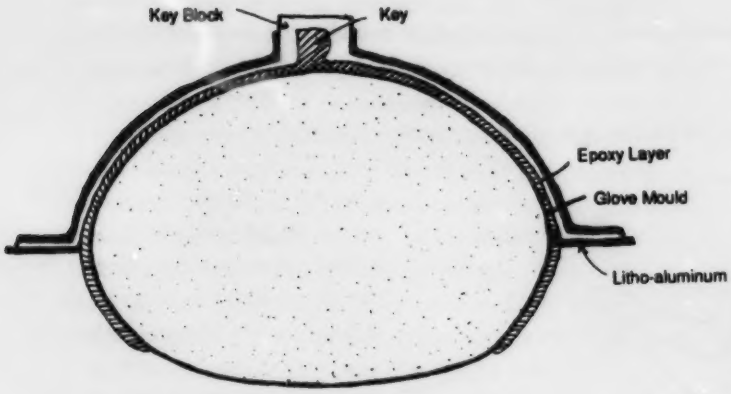
14. Cut out 25 mm (1") squares of nylon stocking. Cut a hole in the centre of each square just large enough to fit over the registration keys. Coat over the tabs at the base of the keys and the areas surrounding the tabs with rubber. Fit a square of nylon over each key and press the nylon's mesh into the wet rubber. Coat the nylon and the areas surrounding the bases of the keys with more rubber and cure it using a heat gun.

15. Apply a fourth layer of rubber, thickened to a stiff paste consistency, to the upper side of the glove mould. Try to avoid trapping air pockets. The rubber must be touching the preceding cured layer to adhere properly. After curing this layer with a heat gun, smooth any rough areas by trimming them with a scalpel blade.

16. Apply a fifth layer of rubber, not quite as thickly filled as the last layer, trying to make its surface as smooth as possible.

17. Turn the model back to the view-side up position and repeat steps 13–16.

18. As the glove mould cannot support itself in its correct shape, a hard shell or jacket must be made to support it. The jacket is laid up with epoxy over the outside of the mould. The registration keys protrude 25 mm (1") from the surface of the mould.



As the jacket does not need to be 25 mm (1") thick overall, boxes can be made around the keys and epoxy can be poured into these boxes, completely covering the keys. When the epoxy cures, blocks are formed with holes that are negative impressions of the positive registration key shape. The "male" registration keys 'pop' in and out of these "female" holes in the blocks. To make the boxes, cut out strips of litho-aluminum about 32 mm by 125 mm (1 -1/4" by 5") long.

Bend each strip into a box (with no top or bottom) and fasten them together with tape. Place the boxes over the registration keys and seal their bases to the mould surface with uncured Sculpy. As Sculpy tends to dry out slightly with time (and lose its seal), pour the epoxy into the boxes on the same day as they are sealed to avoid having the epoxy leak out.

19. Fill each box with Nu-Clear epoxy to a level about 3 mm (1/8") over the top of its registration key. Let the epoxy cure.

20. Remove the metal dams from around the key blocks and carefully clean off any adhering Sculpy. Pop the blocks off and onto the registration keys to make sure they work properly.

21. The jacket is made in sections so that it can be removed from the mould after the mould has been laid up. Fit strips of litho-aluminum where the part lines of the jacket are to be located. Secure and seal the metal strips in place with uncured Sculpy. Apply a Vaseline/toluene release to the metal.

22. Cut fibreglass cloth into 75 mm (3") square pieces and cut an X in the centre of each piece of cloth. Fit them (one per block) over the key blocks. Remove the pieces of cloth and set them aside.

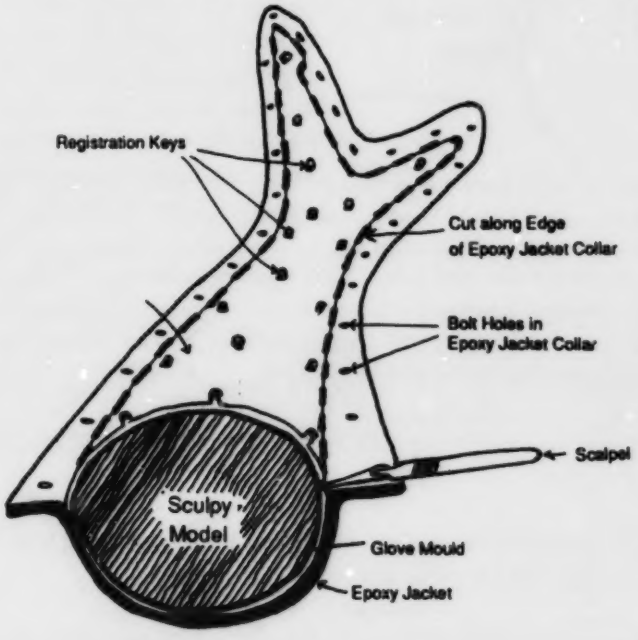
    Mix Nu-clear epoxy (tinted with a pigment to make it easy to see) and thicken it, to a medium paste consistency, with Aerosil filler. Coat the sides of the key blocks and all of the top surface of the mould with the thickened epoxy. Place the pieces of fibreglass cloth over the key blocks and press them into the epoxy. Cut up more pieces of the fibreglass cloth and press them into the remaining uncured epoxy. Run the epoxy and fibreglass cloth out onto the litho-aluminum part dividers for about 38 mm (1–1/2"). This will form the collars used to fasten the jacket pieces together. Let the epoxy cure.

23. Mix Nu-Clear epoxy and enough Aerosil to form a thick paste and heavily recoat the jacket. Cover the collars with another epoxy/fibreglass layer. Add different coloured tints to each epoxy mix to make it easier to see where each layer has been applied. Let the epoxy cure. Apply a third layer of filled epoxy over the entire surface of the jacket. Let the epoxy cure.

24. Turn the mould over so that the back-side is up and repeat steps 18–24 (excepting the addition of litho-aluminum breaks at the part lines—just coat their opposite sides with epoxy/fibreglass).

25. Trim and smooth the jacket's surface to remove any jagged edges and sharp points. Drill holes through the collars and fit them with nuts and bolts. Remove the bolts. Remove the litho-aluminum breaks.

26. Gently and carefully remove the jacket pieces. Clean off any Sculpy left from the dams.



27. After removing the Sculpy model, thoroughly clean the mould before reassembling it in the jacket. Bolt the jacket together and the mould is ready to be cast.

28. In some cases a two-piece glove mould is required. The larger, curved diorama shark model needs a two-piece mould of its tail section because part of the back-side of the tail is visible when the model is exhibited in the diorama. To make a two-piece mould of it, completely encase the model around the tail section with a glove mould. Then build a two-piece epoxy jacket around the tail section with its seams bisecting the tail along the model's ventral and dorsal sides. Remove one side of the tail section of the jacket. Then, using a *very sharp* scalpel, cut all the way through the rubber mould along the remaining jacket's edge. The mould of the tail section is now in two pieces, each with its own jacket. Remove the Sculpy model and reassemble each half of the glove mould into its side of the jacket. The two halves of the glove mould fit together perfectly.

BLUE SHARK (*Prionace glauca*)

CASTING A LARGE, HOLLOW, EPOXY MODEL

IMPORTANT: Read Health Hazard Warning—page 10

1. Assemble the glove mould in its epoxy jacket. Thoroughly mix Nu-Clear epoxy A-side with an equal amount of B-side. Add about 5–7 ml "silk white" iridescent powder plus about 4 ml Hi-lite Blue iridescent powder per 100 ml of Nu-Clear. Add a few drops of Flo-out surface tension breaker to cut down on surface "fish-eyeing". Apply a thin coat of the epoxy all over the mould cavity (head, body and tail areas). Work the epoxy into the mold's texture with a brush while heating it with a heat gun. Continue working over the epoxy with the heat gun, to release air bubbles, evenly coat the mould, and accelerate the cure until it reaches the "toffee" stage (no longer thins when heated). Then let the epoxy stand for several hours to cure thoroughly.

2. Brace the mould's upper edges open with Popsicle sticks so that the mould can not pull away and roll inward from the jacket's upper edges. Recoat the mould using the same procedure as in step 1.

3. Mix 450 ml Sun-cure epoxy (two parts A-side to one part B-side) with about 20 ml "silk-white" iridescent powder plus about 60 ml white microspheres (to whiten and opaque the mix) and about 200 ml Aerosil (to thicken the mix). Sun-cure epoxy takes longer to cure than Nu-clear but it is harder (and more brittle) and it will hold its shape better over this model's large surfaces. This is a *thin* paste that will adhere to the cast's sides but will flow enough so that air pockets will not be trapped between the epoxy layers. Coat the mould cavity all over. This can be done in two half-lots to cut down on the mess. Cut 4 oz. fibreglass cloth into pieces of various sizes (squares and triangles etc., 50 by 50mm, 150 by 150 mm, etc.) and lay them onto the to wet epoxy. Butt the pieces together taking care to *not overlap*, especially on thin tail and fin sections.

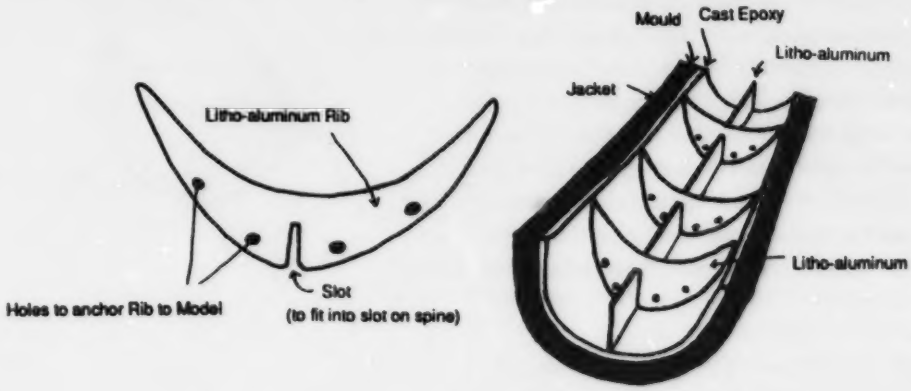
4. Mix 250 ml Sun-cure, microspheres and Aerosil as in step 3 and coat over the fibreglass cloth layer. Let both layers of epoxy cure.

5. Cut litho-aluminum "ribs" for the tail sections and fit them along a "spine" of the same material. Litho-aluminum is very thin and light but is very strong cross-edgewise. Punch holes in the ribs so that epoxy can flow through them. This will anchor the ribs in place when the epoxy cures. Without this mechanical attachment, the epoxy will not bond to the aluminum strongly enough.

6. Mix Sun-cure epoxy as before but add more Aerosil until the epoxy is filled to a thick paste. Trowel it on to the mould and set the ribs and spine construction into place. Cover the construction with the rest of the epoxy mixture, making sure to force the epoxy through the holes in the ribs. Let the epoxy cure.

7. Remove the Popsicle sticks. Clean any excess epoxy from the edges of the mould.

8. The diorama model has a two-piece glove mould of its tail section (See: Blue Shark—Making a large glove mould, step 29). The two halves are laid up separately and then must be joined together. Grind off any lumps on the surface of the epoxy in thin areas such as the tail and fins so that the two sides of the mould will fit together properly. Brush the Vaseline/toluene release agent on the exposed surfaces of the jacket collars to prevent the two sides of the jacket from being epoxied together if the mould leaks. Mix 300 ml of a thickly filled Sun-cure mixture and cover both sides of the mould's two-piece tail section. Fit the mould together and fasten its jacket together with the bolts. Let it cure.



9. Make 150 ml of the more thinly filled Sun-cure mixture. Attach about 60 cm (24") of heat-shrink tubing to a catheter syringe. Turn the mould on its side so that one seam is laying horizontally on the bottom. Pipe the epoxy mixture into the cavity by pushing the tube up into the tail section as far as possible and slowly drawing it out along the seam while pumping the epoxy out of the syringe. Let the epoxy cure.

10. Turn the mould over and repeat Step 9 on the other seam.

11. Mix a thickly filled Sun-cure mixture and coat it over the seam where the body of the shark and the back-side tail section come together. Then lay pieces of fibreglass cloth into the epoxy and let the epoxy cure.

12. The following steps complete the casting of both the one-piece and the two-piece glove moulds. Using more of the thick epoxy mixture, coat the head and the shark's body heavily. Let it cure.

13. Make litho-aluminum ribs for the body cavity in the same way as for the tail section in Step 6. Mix 450 ml of a thick epoxy mixture and embed the ribs in place. Let it cure.

14. Paint the inside of the cast shark with an opaquing paint to prevent any light entering by shining through the view-side's surface onto the back-side opening.

15. Remove the cast epoxy model from the mould after letting the Sun-cure epoxy thoroughly cure (about five days). Attach, with epoxy, an armature to the body cavity's litho-aluminum ribs so that the cast can be mounted on an adjustable stand for further finishing.

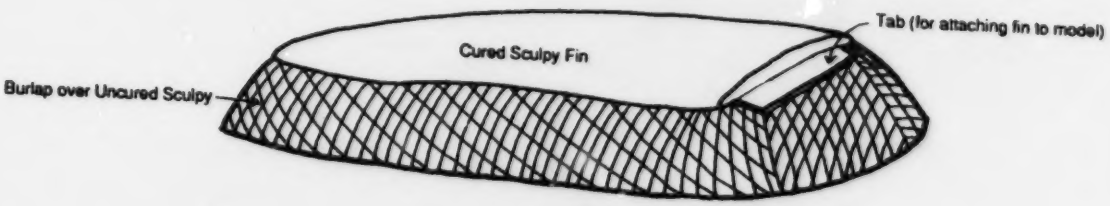
16. Grind out the eyeholes so that the separately manufactured eyes can be installed.

17. Clean up the seams on the model cast in the two-piece mould and fill any holes with tinted Sculpy III (clear). After matching the texture of the shark skin with a stiff bristled brush, cure the Sculpy III patches with a heat gun.

BLUE SHARK *(Prionace glauca)*

Making Large Vacuum-Formed Fins, Assembling and Finishing

1. Prepare the Sculpy/litho-aluminum fins for vacuum-forming by supporting them with uncured Sculpy on a porous base. Form a conelike structure with the model uppermost and the Sculpy sloping away downwards, to the base. Make a clean, crisp join where the Sculpy and model meet. Make sure the support is lower than the model or the heated plastic will not be able to pull down over the model properly and the impression will lack defined detail. Cut out pieces of burlap, fit them over the exposed, uncured Sculpy and press them into place. This keeps the uncured Sculpy from sticking to the vinyl and facilitates the evacuation of the air from under the vinyl during the impression pulling process.



Vacuum-form the fins using 15 mm calendered vinyl. Remove the fins and the uncured Sculpy support from the porous base. Clean the fins thoroughly. Turn them over and resupport them with uncured Sculpy on the porous base. Vacuum-form this reverse side. Cut out the vinyl impressions and fit the two halves together. The edges must meet but not overlap. Tape them together, sealing the join with small pieces of cello-tape. Use a syringe to fill the fins with a thin mix of Sun-Cure, silk white iridescent powder and Aerosil filler mixture. This balloons the vinyl fins so they must be pressed between Styrofoam blocks to hold them in the correct shape while the epoxy cures. Rotate the fins on the rotational molder while the epoxy is curing to keep it evenly distributed over the inner surface of the fins (See: Coho Salmon—Casting a hollow epoxy model using a rotational molder, step 7–9).

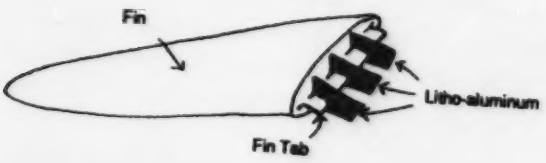
2. Remove the tape from the seams. Use a sharp scalpel blade to clean up the seams. Fill any air pockets inside the fins with epoxy injected with the syringe.

3. Cut slots in the model's body in the appropriate places. Fit the fins to the body by inserting the fin tabs into the slots. Disassemble them from the model. Use a scalpel to remove the vinyl from the fins where they butt up to the epoxy body of the shark. A stronger epoxy-to-epoxy bond will be formed when they are attached.

4. Cut slots across the fin tabs. Cut pieces of litho-aluminum 25 mm (1") longer than the fin tab's depth and about 25 mm (1") wide. Fit these metal strips perpendicularly into the slots in the fin tabs. Attach the metal strips to the fin tabs with 5-minute epoxy. Cut corresponding slots on the shark's

body for these metal strips to slide through when the fins are fitted to the model.

5. Attach the fins *one at a time.* Mix very thick Nu-clear epoxy, silk white iridescent powder, white microspheres and Aerosil filler putty. Apply some of this putty to the outside area of the shark where the fin will be attached. Position the fin on the model, pushing the fin tab and the metal tabs through their slots. Fold over the metal tabs on the inside of the body cavity. Apply more epoxy on the inside of the model over the tabs and outside the model around the join. Sculpt any exposed epoxy to the correct shape and texture while it cures. Hold the fin in the right position with tape and Sculpy while the epoxy cures.



6. Shape and texture around the fins to hide the joins.

7. Paint the shark's entire outer surface with a mixture of white oil paint, Grumbacher matte varnish and turpentine to achieve an even, overall colour. Paint the fins with several coats of the above mixture. Texture the paint, when it is at the "tacky" stage of drying, with a cut-off brush.

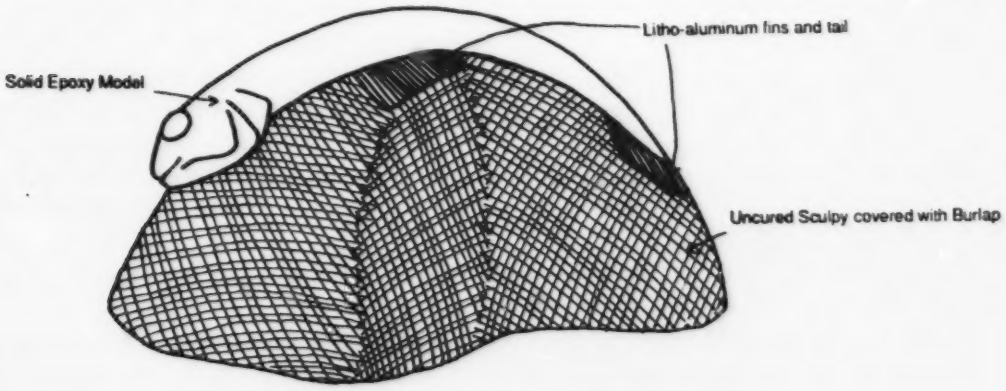
8. Air-brush all over the model with a mixture of "sparkle" iridescent powder and matte varnish thinned to an air-brushable consistency with turpentine. Let it dry. Apply turpentine-thinned oil paint with an air-brush to create rest of the shark's colouration. Use a curator-approved colour sketch, photographs and preserved specimens for references.

9. Make and install the eyes (See: Roughscale Grenadier—Making eyes with lens, page 19).

NORTHERN LAMPFISH *(Stenobrachus leucopsauras)*

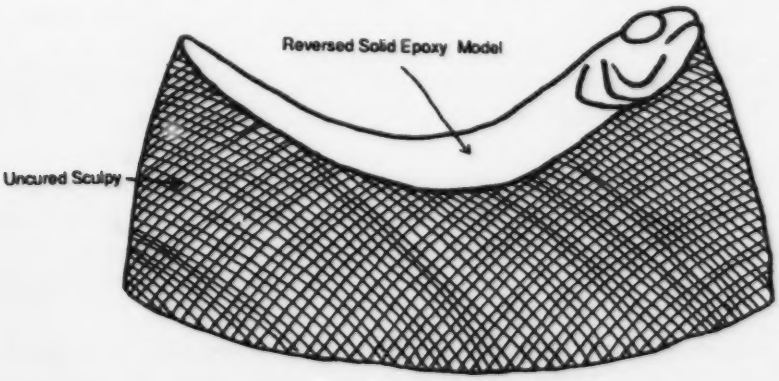
Making a Small, Hollow, Vacuum-formed model with Simple Eyes

1. Fish models that are installed in an underwater diorama by hanging them on the scrims need to be very lightweight. Fish are often exhibited in schooling groups requiring the production of many models in varying attitudes. One solution to both these problems, involving a minimum of model



sculpting and mould making, is to make vacuum-formed vinyl models.

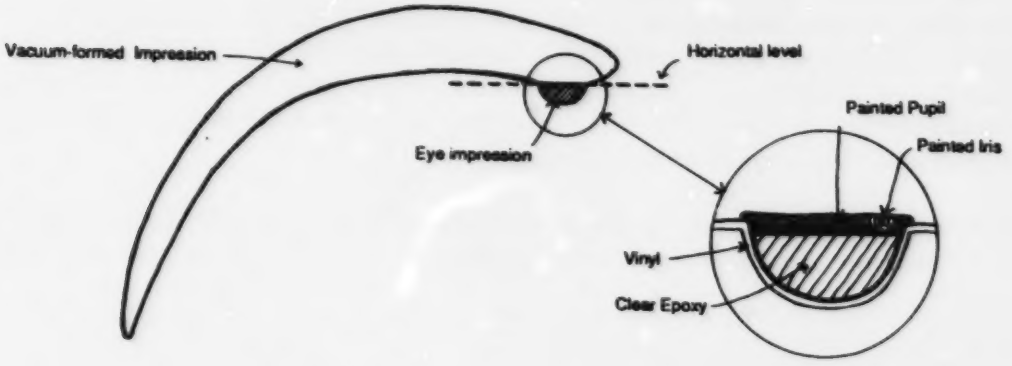
2. Make a two-piece mould from a Sculpy sculpted model (SEE: Roughscale Grenadier—Making a two-piece mould, step 1–13). Cast a solid "plug" in the mould using Sun-cure epoxy (SEE: Roughscale Grenadier—Casting a solid epoxy model in a two-piece mould, step 1–20). This solid plug can be warmed by submerging it in very hot water until it becomes flexible. To avoid uneven stressing, which can cause surface cracking during the shaping process, be sure to leave the plug in the hot water long enough to be warmed all the way through. Gently manipulate the warmed plug into the



desired position and hold it in that position until the epoxy cools and becomes firm again. Many vacuum-formed vinyl impressions can be taken of both the back and the front sides of this curved plug. The plug can be rewarmed and reshaped into many different attitudes and multiple vacuum formed impressions can be made of each variation.

3. Prepare the epoxy plug for vacuum-forming by supporting it with uncured Sculpy on a porous base. Form a conelike structure with the model uppermost and the Sculpy sloping away downwards, to the base. Make a clean crisp join where the Sculpy and model meet. Make sure the support is lower than the model or the heated plastic will not be able to pull down over the model properly and the impression will lack defined detail. Cut out pieces of burlap, fit them over the exposed, uncured Sculpy and press them into place. This keeps the uncured Sculpy from sticking to the vinyl and facilitates the evacuation of the air from under the vinyl during the impression pulling process. If the model is small it will have very delicate tail, dorsal & pelvic fins. Remove the epoxy fins and tail and replace them with pieces of litho-aluminum cut out in the shape of the epoxy ones. Vacuum form as many impressions as required.

4. Remove the plug from its support and turn it over. Prepare the plug in this reversed position in the same way as described in Step 3. Because the fins should be only one layer of vinyl thick on the finished model, only the one half of the vacuum formed impression needs to have fins. Either remove the litho-aluminum fins from the plug before vacuum forming the second half of the fish or cut off the extra set of fins when cutting the impression out of its vinyl sheet. Vacuum form the same number of impressions of this side as were made of the first side in Step 3.



5. Carefully cut out the vinyl impressions and match front and back pairs. The edges should meet but not overlap. The edges can be lightly sanded to perfect the fit.

6. If there are fins on both halves, remove them from one half. Scrape the remaining fins with a scalpel blade to a fine, feathery edge and score them with a modelling tool to simulate the fin rays.

7. Support each fish half with the eye positioned horizontally. Fill the eye depression with clear Nu-Clear epoxy and allow it to cure. Paint a pupil and then an iris with acrylic paint on the back surface

of the epoxy filled eye. This produces a simple eye.

8. Paint the inside of each vinyl impression with white, iridescent acrylic paint. Paint the inside of each impression with two coats of an opaquing paint, if the model is going to have a bioluminescent effect when installed.

9. Fit the two halves of the fish together. Use small strips of cello tape to carefully join and seal the seam where the edges meet.

10. Cut a small hole on the back side of the model. The hole should be only large enough to fit a syringe needle through.

11. Mix 10 ml of Sun-cure epoxy with opaque white pigment and a small amount of Aerosil. The mixture should be quite runny. Use a syringe to inject this mixture into the model. Seal the hole with a piece of tape. Slowly rotate the model to slosh around and distribute the epoxy mixture over the entire inside of the model. The Aerosil in the mixture helps the epoxy adhere to the vinyl's surface. Tape the model onto the rotation moulder and rotate it while the epoxy cures. This keeps the epoxy evenly distributed over the inside of the model, preventing it from pooling in one end. Allow 12 hours curing time before removing the model from the rotation moulder.

12. Remove the tape and refine the finish along the seams. The two vinyl halves are now joined together by the thin inner shell of epoxy. A light-weight, hollow model has been created.

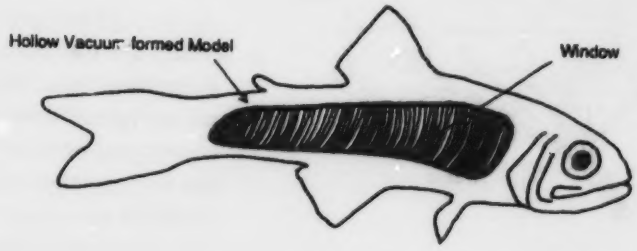
13. Draw the pectoral and pelvic fins on a piece of thin acetate (.005 ml). Add a tab to each fin for installation purposes. Use a scalpel blade to score the outside edges (excepting the tab) and to simulate fin rays. Scrape, feathering the edges, until the fin separates from the acetate without being cut out. Cut out the tab section. Cut a slot in the model where the fin tab is to be inserted. Dip the tab into a cyanoacrylate glue (e.g., Crazy glue, Lock-Tite, etc.) and insert the tab into the slot. Hold it in position until the glue sets in about 30 seconds.

14. Paint the exterior of the model with turpentine-thinned oil paints. Use a curator-approved colour sketch for reference. If a bioluminescent effect is to be installed, attach the pectoral and pelvic fins

NORTHERN LAMPFISH *(Stenobrachus leucopsauras)*

Installation of Bioluminescent Effect in a Small Model

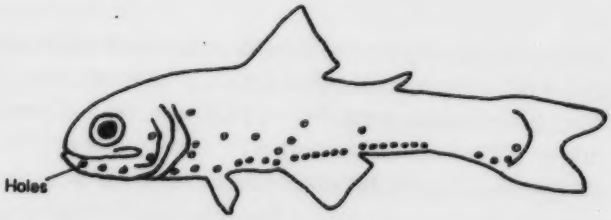
1. Cut a "window" about 6 mm by 50 mm (1/4" by 2") in the back-side of the model (See: Northern Lampfish—Making a small, hollow, vacuum formed model).



2. Determine the sizes and positions of the fish's photophores with the assistance of the curatorial staff.

3. Use appropriate sizes of fine drill bits to carefully drill photophore holes through the model from the view-side.

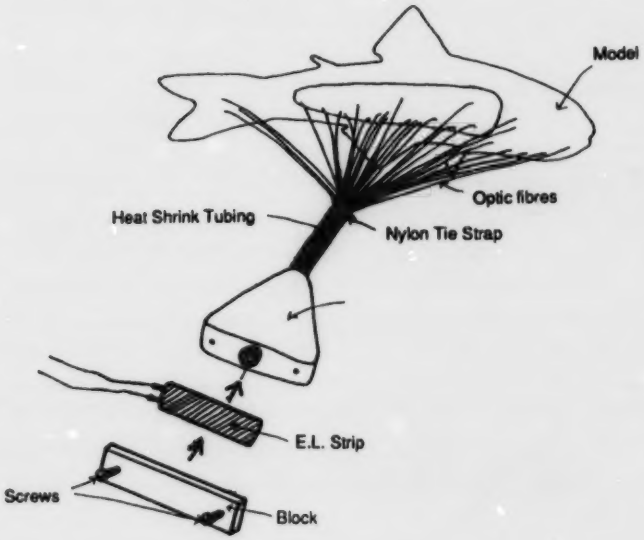
4. Cut lengths of acrylic fibre optic strands about 25 cm (10") long (The fibres are available in various diameters). Use fibres that correspond to the photophores' sizes.



5. Thread the optic fibres through the holes. Leave about 3 mm (1/8") of fibre protruding out the view-side of the model. Affix the fibres into their holes with 5-Minute epoxy. Let the epoxy cure. Tightly bundle the fibres together on the back-side of the model by tying them together with a nylon tie strap. Feed the end of the bundle of fibres through a 12.5 cm (5") piece of black heat-shrink tubing. Push the tubing along the strands up to the nylon tie. Heat the tubing, with a heat gun, to shrink the tubing tightly around the fibres. Be very careful during this procedure not to melt the plastic fibres. Trim the ends of the fibres flush with the end of the tubing. The fibres and tubing form an optic cable along which light can be transmitted.

6. Mix epoxy with opaque black and metallic pigments and coat the exposed surfaces of the fibres between the model and the tubing. This opaque coating will prevent light from escaping through the sides of the fibres while it is being transmitted along them.

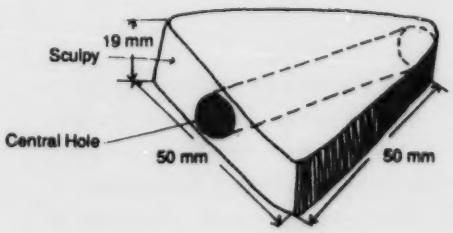
7. An electro-luminescent lamp (E.L. strip) will be the light source for the Bioluminescent effect. One E.L. strip measuring 13 mm (1/2") by 32 mm (1–1/4") will be used per fish.

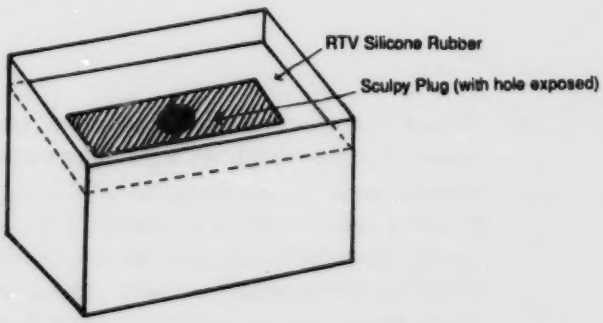


8. To affix the E.L. strip to the end of the optic cable, without light leaks, an "end plug" is needed. As several end plugs are required (one per fish model) a mould will be made for manufacturing them. Make a triangular shaped block out of Sculpy measuring 50 mm (2") on each side by 19 mm (3/4") deep. Run a hole the size of the optic cable diameter through the center of the block from the top of the triangle out through the bottom of its base.

   Bake the Sculpy in an oven for 15 minutes at 176° C (350° F).

   Construct a mould box (SEE: Deep Sea Skate—Making a one piece mould, step 4–6) with inside dimensions of 75 mm by 44 mm by 63 mm high (3" by 1–3/4" by 2–1/2"). Support the baked Sculpy plug inside the mould box with its pointed end down. Seal the opening of the centre hole at the lower end to prevent the moulding rubber from seeping up into it. Fill the mould box with RTV silicone rubber (SEE: Deep Sea Skate—Making a one piece mould, steps 7–11) up to the level of the top of the Sculpy plug. Let the rubber cure.





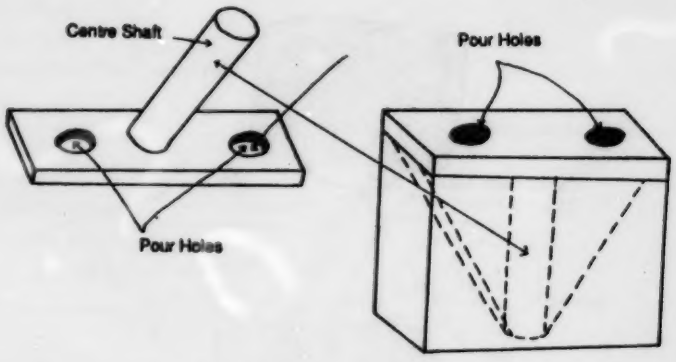
Remove the uncured Sculpy sealing the bottom of the plug's center hole. Coat the inner sides of the hole, the top of the plug and the exposed top of the cured R.T.V. rubber with toluene/Vaseline release agent. Pour in enough RTV silicone rubber to fill the hole and cover the top of the plug by 3mm (1/8"). Let the rubber cure. This makes a two-piece mould of the plug.

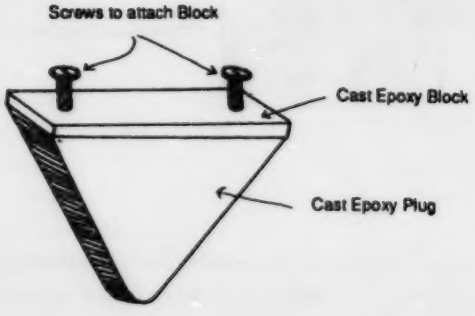
9. Remove the Sculpy plug from the mould. Clean the mould.

10. Sculpt a rectangular block 50 mm by 19 mm by 3 mm(2" by 3/4" by 1/8") deep in Sculpy and bake it. Make a one-piece mould of it (SEE: Deep Sea Skate—Making a one-piece mould, step 4–12).

11. For casting purposes, cut pour holes through the top section of the plug mould, one on each side of the centre shaft.

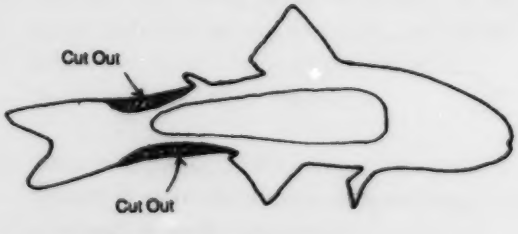
12. Mix 20 ml of Nu-Clear epoxy. Assemble the plug mould and fill it through the pour holes in its top section. Fill the one-piece rectangular block mould. Let the epoxy cure.



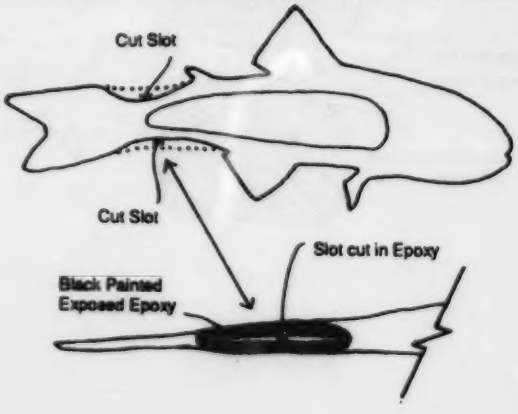


13. Remove both epoxy casts from the mould. Position the rectangular block over the base of the plug. Drill two tiny holes, 6 mm (1/4") in from the ends, down through the block and into the plug. Tap threads into these holes so that screws can be fitted to attach the block to the plug.

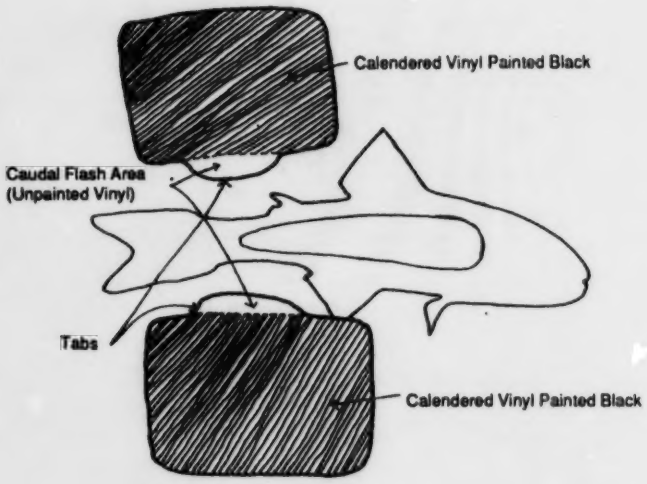
14. Mix 5-minute epoxy and coat the inside of the hole through the plug. Feed the fibre optic cable (the fibre optic strands from the model encased in heat-shrink tubing) through the plug's hole from the triangle's pointed end to its base. The end of the cable is flush with the outside of the plug. Support the plug horizontally with its base uppermost. Pour more clear 5-minute epoxy over the end of the



View of Under and Top Sides



optic cable exposed in the centre of the plug's base. Let the epoxy cure thoroughly. Polish the epoxy-coated end of the cable to a very smooth surface, first with very fine sand paper and then with a plastic polish. This improves the optical quality of the fibres.

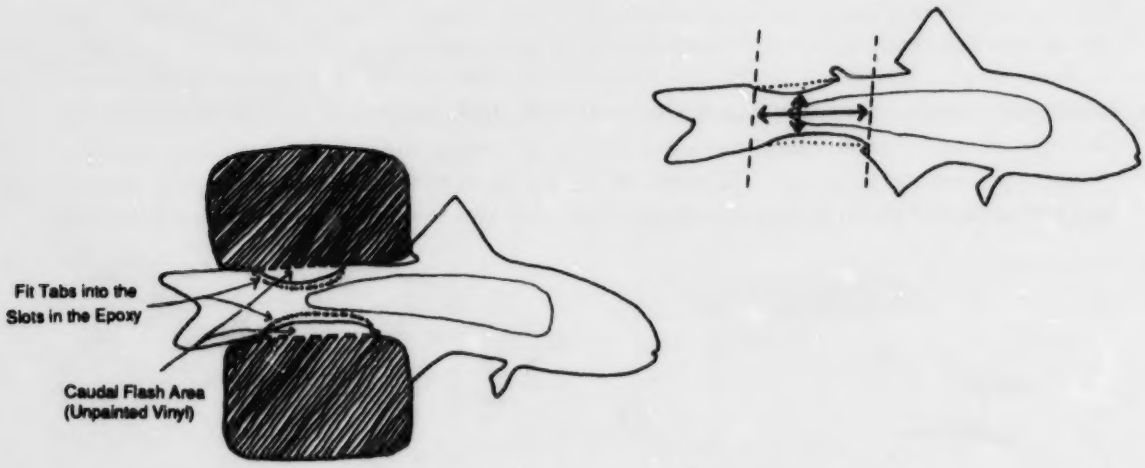


15. Lay a wired E.L. strip over the end of the optic cable in the plug with the illuminating surface to the cable. Place the epoxy rectangular block on the base of the plug, sandwiching the E.L. between itself and the plug. Fasten the block to the plug with screws.

16. Clip off the optic fibres protruding from the fish's view-side, so they are flush to the surface of the model.

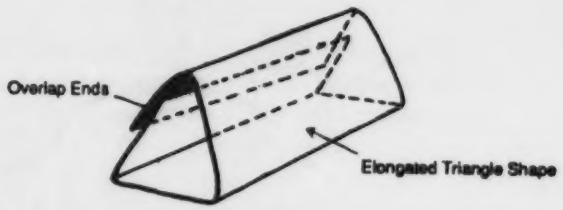
17. Paint the model with turpentine-thinned oil paints. Do not paint over the ends of the optic fibres.

18. In addition to the photophores, the Northern Lampfish have bioluminescent displays called caudal flashes, which mean that areas along the top and bottom of the caudal (the trunk of the tail section) light up. A separate effect needs to be built into the model to create these caudal flashes.

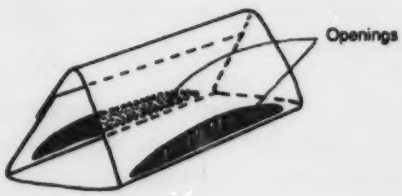


19. The caudal flash effect is built into the model preceding installation of the photophore effect. Cut the "window" in the back-side of the model as in Step 1 of this chapter. Next, cut out and remove the areas on the caudal where the flashes are located. Be careful *not* to cut right through the layer of epoxy inside the outer vinyl layer.

20. Cut a slot into the epoxy exposed by removing these pieces in the caudal flash area. Make the slots perpendicular to the back and belly of the model. Paint the cut-out area and the slots with opaquing black paint.



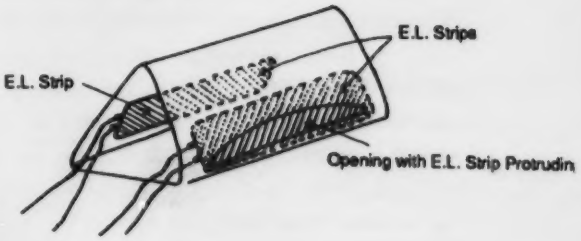
21. Cut out two pieces of calendered (the texture acts as a light diffuser) vinyl with tabs that fit into the slots in the caudal flash area (see diagram opposite page). Paint the vinyl with opaque black paint except in the caudal flash area.



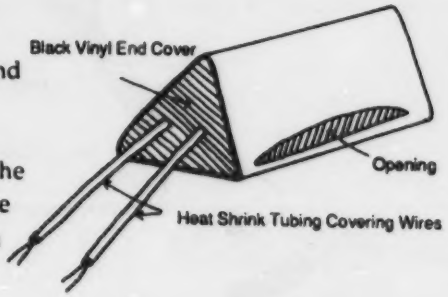
22. Fit the vinyl pieces into the slots in the epoxy.

23. Drill the photophore holes and attach the fibre optic threads as in Steps 2–6 in this chapter.

24. A unit to provide the light source for the caudal flashes must be manufactured. Measure the length of the caudal flash cut-outs on the model and the width of the area between them. Cut out a rectangle of opaque black vinyl slightly longer than the caudal flashes and slightly more than three times the width of the area between them.

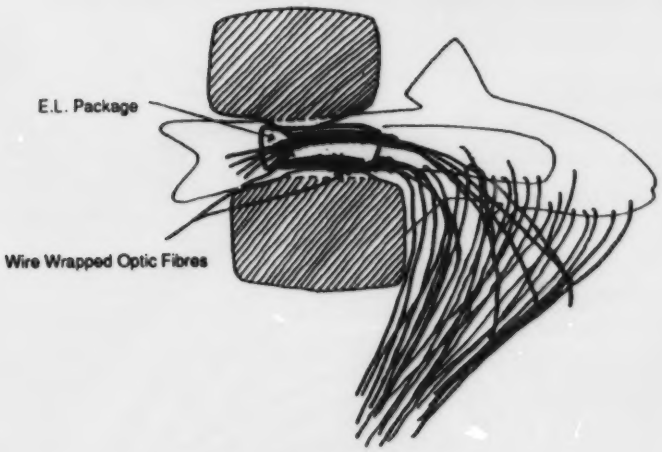


Fold the vinyl into an elongated triangle shape with each side measuring slightly less than the distance between the caudal flash cut-outs. Overlap the ends of the vinyl where they meet and glue them together.



25. Cut out an opening along the bottom of each of the upper sides of the triangular shape (but not in the base) corresponding with the unpainted areas on the vinyl attached to the model.

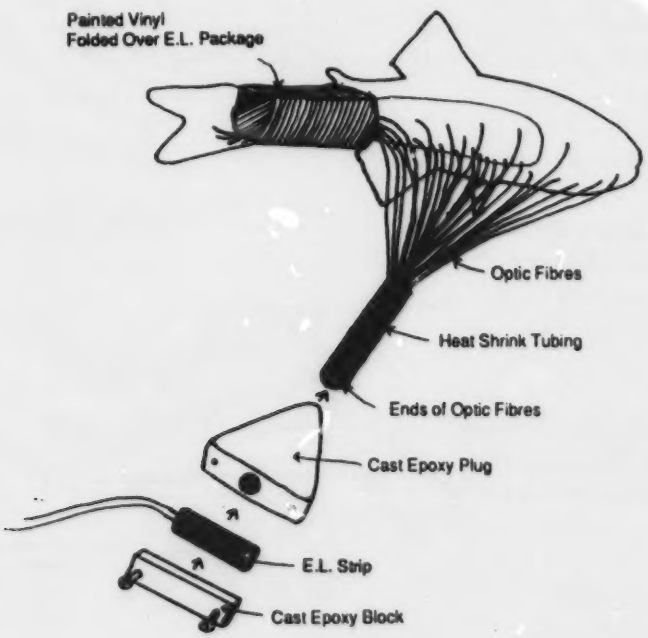
26. Affix two prewired E.L. strips (one to each opening), with the illuminating surfaces facing outward, over the openings.



27. **Cut out triangles from opaque black vinyl and fit them into the ends of this E.L. package to keep the light enclosed. Feed the wires from the E.L. strip through holes cut in one of the end pieces and then encase the wires with heat-shrink tubing.**

28. Position the E.L. package on the caudal between the caudal flash cut-outs so that the openings in the package line up with caudal flash areas and the unpainted vinyl film. Epoxy it in place with 5-Minute epoxy.

29. Bundle the optic fibres in the tail area and wrap them with wire. Bend the wire-encased bundle so that it passes above the light opening in the E.L. package and secure it in that position. Bundle and secure the optic fibres running below the E.L. package so that they will not interfere with the light transmission from the E.L. package.



30. Fold the painted vinyl over the E.L. package and fasten it neatly in place with cyanoacrylate glue. Coat the whole unit with opaque, pigmented epoxy to ensure it will hold together.

31. Bundle the optic fibres and affix their light source (see steps 8–18).

COHO SALMON *(Onchothyrchus kisutch)*

Bending a Large Solid Epoxy Model for Vacuum-Forming Models

(SEE: NORTHERN LAMPFISH, page 46)

1. Sun Cure epoxy or an equivalent slow-curing epoxy (24 hour set/72 hour cure) should be used to cast the solid model because, even though the faster-curing epoxy formulations can be shaped using this method, they will tend to creep back to their original configuration over time and because of the warming involved in the vacuum-forming process.

2. For a large model, such as this Coho Salmon, the epoxy plug will have to be heated in hot water for up to eight hours to be heated sufficiently all the way through to its centre core. If it is not heated right through, uneven stressing can cause cracks to develop on the model's surface. When the correct temperature is reached, the model's thin sections will be very soft (and fragile!) and the main body will bend under a constant pressure.

3. To heat the model, submerge it in a container filled with enough water to just cover it. The container must be made of a material, such as stainless steel, that can be heated. Use an electric hot plate, barely touching the underside of the container, to heat the water. Maintain the water temperature at just below the boiling point (bubbles forming but not actively releasing around the hot plate element area). Place a cover over the top of the container to keep the temperature even. Check periodically to make sure the water has enough depth to cover the model. Top it up when necessary.

4. When the model is heated through, remove it from the bath. Rest its tail section on a solid surface. Hold its head in one hand while applying pressure along the mid-body with the other hand until the desired bend is achieved. Hold the model in this shape while an assistant runs cold water over the model to cool it. When the model is sufficiently cooled it will solidify in this new position. After the main body has cooled and set, individual fins can be reheated with a heat gun to accommodate final shaping. The model can be reheated in the water bath to either return it to its original posture or to reshape it again.

5. The "plug" is now ready to be prepared for vacuum-forming (SEE: Northern Lampfish—Making a small hollow vacuum-formed model with simple eyes, step 3–4).

COHO SALMON *(Onchathyrchus kistch)*

Painting and Finishing a Vacuum-Formed Diorama Model

1. Prepare and vacuum-form vinyl impressions from the solid epoxy model (SEE: Coho Salmon—Bending a large solid epoxy model for vacuum-forming models, step 1–4 and Northern Lampfish—Making a small, hollow, vacuum-formed model with simple eyes, step 1–4).

2. Cut out the vinyl impressions, build in simple eyes, join the two halves of the model together and fabricate and install the fins (SEE: Northern Lampfish—Making a small, hollow, vacuum-formed model with simple eyes, step 5–13).

3. Where needed, give the model a general clean-up and light sanding to prepare it for painting. Mask the eyes with several coats of acrylic medium (such as Rhoplex). The models for the underwater diorama are painted in such a way as to give the impression of the fish's colours as seen by light travelling through and diffused by the water rather than their actual colours.

4. Airbrush an overall white base coat made up as follows:

   1 part —White oil paint
   2 parts—Japan Dryer
   4 parts—Grumbacher Oil Paint Resin
   8 parts—Thinners

5. Air brush on 2 or 3 coats of dorsal (back) surface colour:

   4 parts— Payne's Grey
   2 parts —Mars Black
   1 part —Permanent Blue
   5 parts—Japan Dryers,
   7 parts—Grumbacher Oil Paint Resin
   10 parts–Thinners

6. Mask all the fins and the tail with paper and tape. Apply one coat of silver lacquer spray paint (from a spray can) above the lateral line and blending into the dorsal colour

7. Add iridescent pearl powder to thinned, white oil paint and air brush it onto the model along the belly, the chin and any other white areas on the fish's body.

8. On top of these layers, most thickly along the centre line of the fish, apply a coat of sparkle iridescent powder. Sprinkle the sparkle lightly onto a coating of Grumbaucher's oil paint resin and damar varnish. A shaker can be made by taping a piece of vinyl over the top of a small bottle filled with iridescent sparkle powder and then perforating the vinyl with fine holes.

9. When the sparkle is dry remove the fin masking. Make a second, thicker dorsal colour mix as follows:
   4 parts—Paynes Grey
   2 parts—Mars Black
   2 parts—Japan Dryers
   3 parts—Grumbacher Oil Paint Resin
   5 parts—Thinners

   Hand paint the tail, fins, head and mouth with this colour. Use it along the dorsal surface to blend and slightly redarken it. Hand brush the caudal fin to add detail colour and to emphasize the relief.

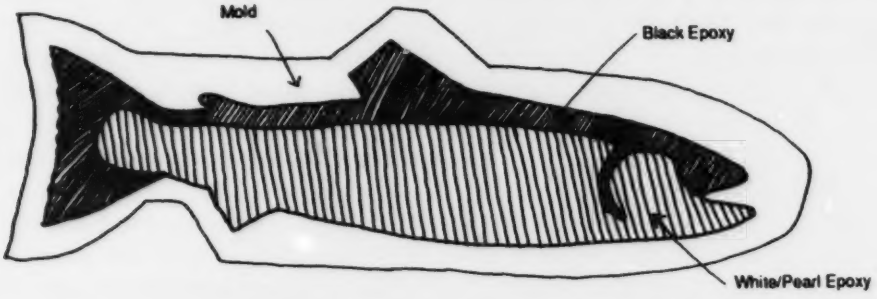
10. Prepare the pectoral and anal fins for painting by giving them a thick coating of 5-minute epoxy with pearl iridescent powder mixed into it. Paint them with the white and the dorsal colours. Glue them, with cyanoacrylate glue, into slots cut into the model's body .

COHO SALMON *(Oncorhynchus kistch)*

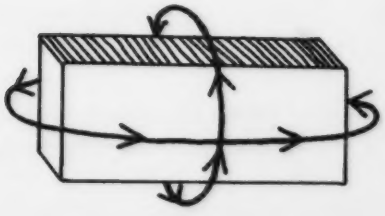
Casting a Hollow Epoxy Model Using a Rotational Moulder

1. Remove the pectoral and pelvic fins from the Sculpy model. Make two-piece moulds of the model and of the separated fins. (SEE: Roughscale Grenadier—Making a two-piece mould, step 1–12).

2. Lay up the mould with a mix of Nu-Clear epoxy and a few drops of Flo-Out surface tension breaker (SEE: Roughscale Grenadier—Casting a solid model in a two-piece mould, step 1–15). Use clear epoxy for the first two lay-ups. Then make two mixtures of epoxy: one with black pigment added and the other with white pigment and pearl iridescent powder. Apply the black epoxy to the top third of the fish's body and the white/pearl epoxy to the remaining two-thirds. Let the epoxy cure.



3. Apply a layer of white epoxy, heavily filled with Aerosil, all over the mould. Cut fibreglass cloth into 75–100 mm (3"– 4") pieces (squares, oblongs, etc.). Make a layer of them all over the uncured epoxy and press them into it. Cover the fibreglass cloth layer with another coating of more thinly-filled Nu-Clear epoxy and allow the layers to cure. Apply another layer of fibreglass cloth and epoxy and let it cure. This cast needs this fibreglass reinforcing layer because it will be necessary to press firmly onto the model's outside surface when applying the hot transfer foil at the "silvering" stage.



4. Carefully clean and scrape the epoxy along the seam edges. Remove any excess epoxy that might interfere with the two halves of the mould fitting snugly together.

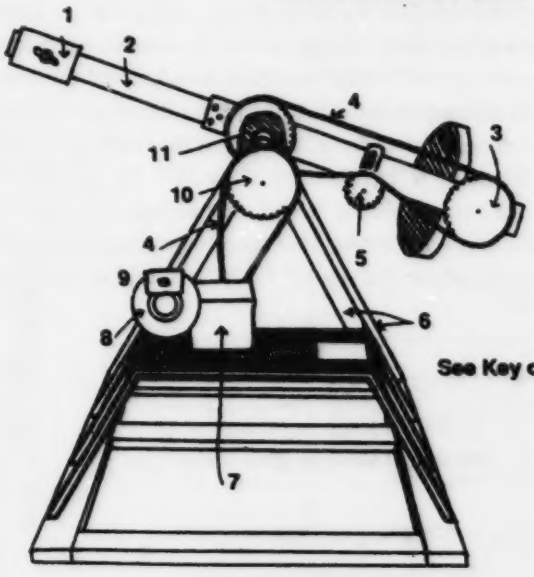
5. Estimate the amount of epoxy needed to fill one third of the mould cavity. Mix this amount of epoxy and add a little white pigment and Aerosil. The Aerosil is added to help the epoxy adhere to the inside walls of the cast. Pour the epoxy into one half of the mould. Brush the epoxy onto the fins and tail. Carefully place the other half of the mould on top of the filled half and work the registration keys securely together. Clamp the mould between two boards to hold the two halves of the mould together. Be careful not to overtighten the clamps so as not to distort the shape of the mould and cause leakage or an uneven seam line. Masking tape can be used to hold smaller moulds together instead of using boards and clamps. Slowly turn the mould

over by hand from side to side and from end to end to distribute the epoxy over the seams and the inside of the mould cavity. Work quickly as large volumes of epoxy generate heat and cure faster than usual. The inner shell of epoxy will fuse with the previous lay-ups and join them together to form a hollow one-piece model when it cures.

7. To keep the epoxy distributed over the inside of the mould instead of collecting in its lowest point, a method of continually turning the mould until the epoxy cures is needed. The mould can be fastened to a rotation moulder machine, also known as a slush moulder. This device rotates the mould in two planes or axes at the same time - side over side and bottom over top.

Diagram 1

Rotational Moulder (Side View)



See Key on Page 61

8. The rotational molder used in making the Open Ocean models was fabricated in the Royal British Columbia Museum metal shop. The following is a brief description of its construction: (Refer to the diagram for clarification.)

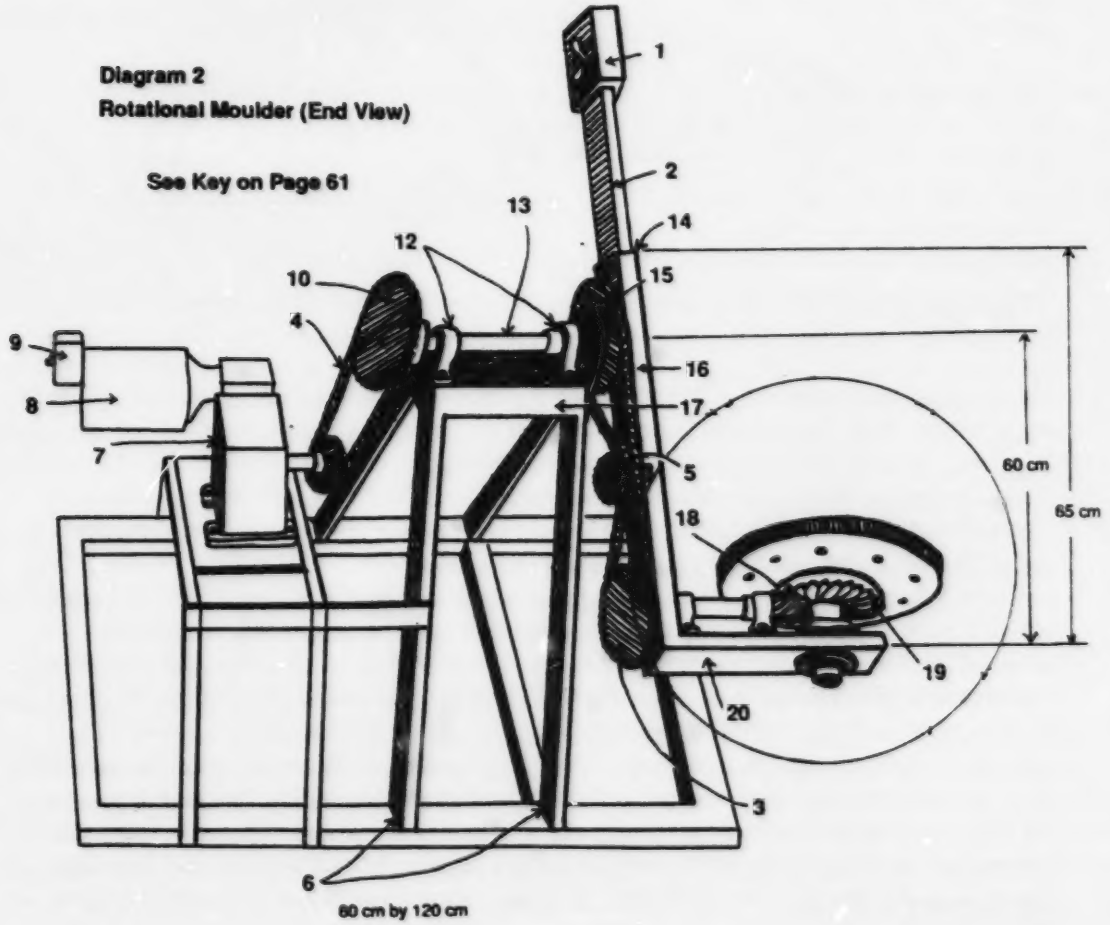
The *Rotating Arm* is made from 50 by 75 mm (2" by 3") rectangular steel tubing cut and welded into an "L" shape. Its dimensions are 66 cm (26") on the long *Vertical Arm* and 33 cm (13") on the shorter *Horizontal Leg*. A *Crown Gear*, from an automotive differential, is mounted on a 25 mm (1") diameter *Shaft*. The shaft is installed through the horizontal leg 25 cm (10") out from the vertical arm. It passes through *Bearings* with *Locking Collars* mounted on the top and bottom sides of the horizontal leg. A 31 cm (12") round, steel plate is mounted on top of the crown gear to form a rotating *Table* onto which the moulds can be attached during rotational molding. A 31 cm (12") round piece of 25 mm (1") plywood is bolted to the steel table to facilitate attachments. A *Pinion Gear*, from the automotive differential, is mounted on the end of another 25 mm (1") diameter shaft. The shaft is mounted in bearings bolted to the top of the horizontal leg. The pinion gear engages the crown gear on one end of the shaft. The other end of this shaft passes through the vertical arm and a *Chain Sprocket* is fastened to it. This is the *Table Drive Chain Sprocket*. A 25 mm (1") diameter *Main Drive Shaft* is welded to the vertical arm 60 cm (24") up from the horizontal leg. The shaft is parallel to the horizontal leg but projects from the opposite side of the vertical arm. The main drive shaft passes through two bearings which are mounted to a piece of (2" by 3") rectangular steel tubing. This is welded to the peaks of two *Support "A" Frames* made from 25 mm by 50 mm (1" by 2") rectangular steel tubing. On one side of the support "A" frames (next to the rotating arm) a *Fixed Chain Sprocket* is welded to the frame. A chain is fitted onto the fixed chain sprocket and onto the

table drive chain sprocket. A movable *Idler Sprocket* is mounted on the vertical arm, halfway between the other two sprockets, for adjusting the chain's tension.

The opposite end of the main drive shaft also has a chain sprocket mounted onto it. This is the *Main Drive Chain Sprocket* which is driven from the power source. The power source is a one-quarter HP (1750 RPM) electric motor on a 200-to-1 *Reduction Box*. The chain sprocket on the shaft coming out of the reduction box is a 24-tooth sprocket while on the main drive shaft, it is a 48-tooth sprocket. The speed of the shaft coming out of the reduction box has been reduced to 8.75 RPM. With a 2-to-1 ratio between the reduction box shaft sprocket and the main drive shaft sprocket, the working speed of the rotating arm is 4.375 RPM. The ratio of the crown to the pinion gears is about 4-to-1 so that for each revolution of the rotating arm the table revolves a quarter turn. The machine also has a 1.3 cm by 7.5 cm by 60 cm (1/2" by 3" by 24") flat *Counter Balance Bar* bolted to the top of the vertical arm. On the bar is a *Sliding Weight* that adjusts to counterbalance the weight of anything that is attached to the revolving table. This machine can accommodate a mould with dimensions of up to 40 cm by 40 cm by 93 cm (16" by 16" by 36") weighing about 36 kg (80 lbs.).

Diagram 2
Rotational Moulder (End View)

See Key on Page 61

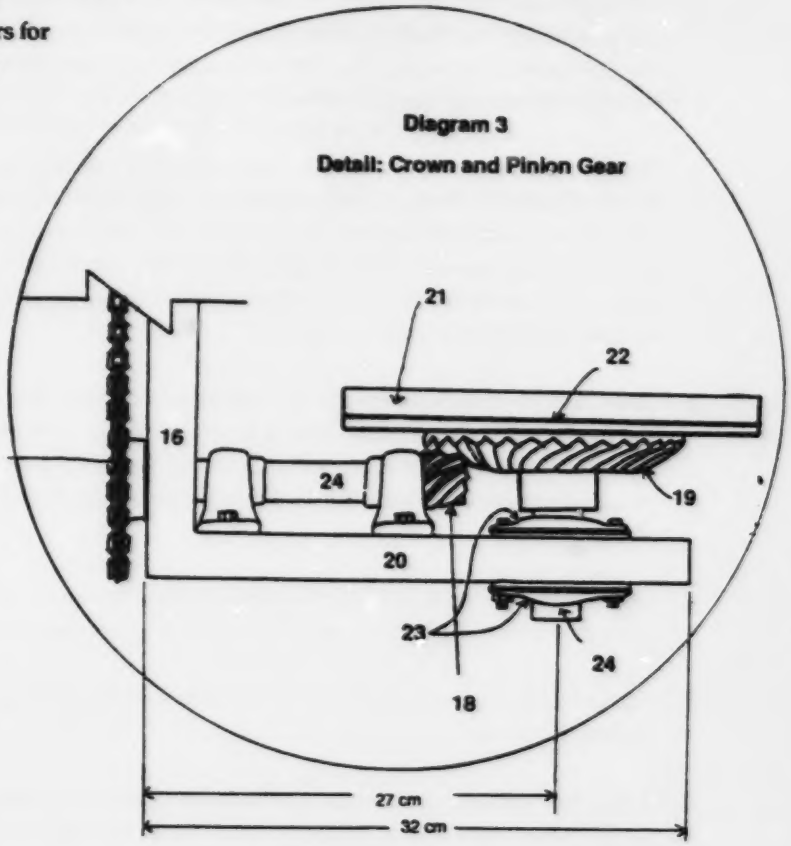


9. When the moulder is rotating, the epoxy will tend to stay where it has already been distributed in the mould's cavity. Rotate the mould until the epoxy is sure to have cured enough to cease flowing (about four hours for Nu-Clear epoxy). Remove the mould from the rotation moulder but do not attempt to remove the cast until the epoxy is completely cured (another 12 hours for Nu-Clear epoxy). Even though it will no longer flow, the epoxy won't be hard enough yet to retain its shape.

10. Cast the fin moulds. Remove all the casts from the moulds and scrape, fill, sand, refine and generally clean them up as necessary. Grind out the eye sockets and fin-mounting slots.

Diagram 3

Detail: Crown and Pinion Gear



Key for Diagram 1-3

1. Sliding Weight
2. Counter Balance Bar
3. Table Drive Chain Sprocket
4. Chain
5. Idler Sprocket
6. Support A Frames
7. Reduction Box (200-to-1)
8. Electric Motor
9. Switch
10. Main Drive Chain Sprocket
11. Fixed Chain Sprocket
12. Main Drive Shaft Bearings
13. Main Drive Shaft (welded to rotating arm)
14. Rotating Arm
15. Fixed Chain Sprocket (welded to support A)
16. Vertical Arm
17. Rectangular Tubing
18. Pinion Gear
19. Crown Gear
20. Horizontal Leg
21. Plywood Bolted to Table
22. Table
23. Locking Collars and Bearings
24. Shaft

COHO SALMON *(Onchothyrchus kisutch)*

Silvering Technique for an Epoxy Fish Model

1. A model that is to be exhibited in a showcase situation, rather than in the underwater diorama like the previously described vacuum-formed Coho Salmon models, requires a detailed representation of the fish's actual colouring. The Coho Salmon, like many other fish, appears to have a highly reflective silver over parts of its body.

2. Remove the cast epoxy model from the mould and refine it as necessary in preparation for final colouring and finishing. Paint green pearl iridescent powder mixed with vinyl sealer onto the top third of the model from its top down to 19 mm (3/4") below its counter-colouration line (the line where its dark top and meets its light underside). Brush black-tinted vinyl sealer onto the fins. Use vinyl sealer as the medium for a series of colour tints using pigments, iridescent powders and dyes to achieve the final colours for the fins.

3. Brush a mixture of 5-minute epoxy, thinned with lacquer thinner, over the midsection and bottom of the model's sides from the counter-colouration line to within 50 mm (2") of its bottom. The thinned epoxy will cure but its surface will remain slightly tacky. Brush Aluminum Lining Bronze (a silver powder) onto this tacky surface and then brush off any excess. This produces a translucent silver effect.

4. Use various brushing and stippling techniques to colour the details (upper back, head, mouth, chin, gills, etc.) with various dyes, pigments and iridescent powders in vinyl sealer.

5. Produce teeth from single-strand acrylic fibre and install them, with 5-minute epoxy, into holes drilled in the jaw.

6. Apply hot stamping foil (silver) to the midsection of the model's body using a heated roller. Support the model securely with its sides in a horizontal position.

   Cut a piece of foil large enough to apply to the whole area to be silvered in one piece because joins or lapped edges tend to be apparent. Apply the foil, beginning along the lateral line, by rolling with the pre-heated roller. A fair amount of pressure is needed to affect the transfer of the foil with good adhesion. When the main area is thoroughly rolled, use a woodburning tool to detail the foil. Set it at 163°C (325°F) by plugging it into an outlet controlled by a rheostat switch. Modify the tip of the tool by hammering, filing, and polishing it to a shape and size approximating an average Coho Salmon scale. Impressions to each scale with this tool will obtain a complete coverage and transferring of the foil. When all of the foil has been adhered and detailed, strip off the mylar carrier sheet and carefully patch minor discrepancies. If the foil has covered up and/or filled in some of the lines of separation between the scales use a sharp dental tool to meticulously remove it.

7. Fit the pectoral and pelvic fins into the previously prepared slots and attach them with 5-minute epoxy. After they are attached, brush thinned 5-minute epoxy over the join. Dust the silver powder (aluminum lining bronze) over the surface of the epoxy when it has cured but is still slightly tacky. Remove any excess powder. Overpaint the transition at the upper margin of the foil with Hi-lite

pearl iridescent powder in vinyl sealer. Taper off the overpainting four to five lines of scales above the foil and blend it down to near the lateral line.

8. Dry rub the silver powder over the bottom half of the model's body from the lateral line down, blending it into the white of the belly. The silver powder can also be applied to the cheeks, chin, jaw, etc., and can be used as a blender at the margins of the foil and other appropriate areas.

9. When the final colouration is satisfactory, wash the top two-thirds of the model (including the fins) with a matte lacquer containing some blue Hi-lite pearl iridescent powder.

10. Produce and install complex eyes (SEE: Roughscale Grenadier—Making eyes with lenses, step 1–15).

VAMPIRE SQUID *(Vampyroteuthis infernalis)*

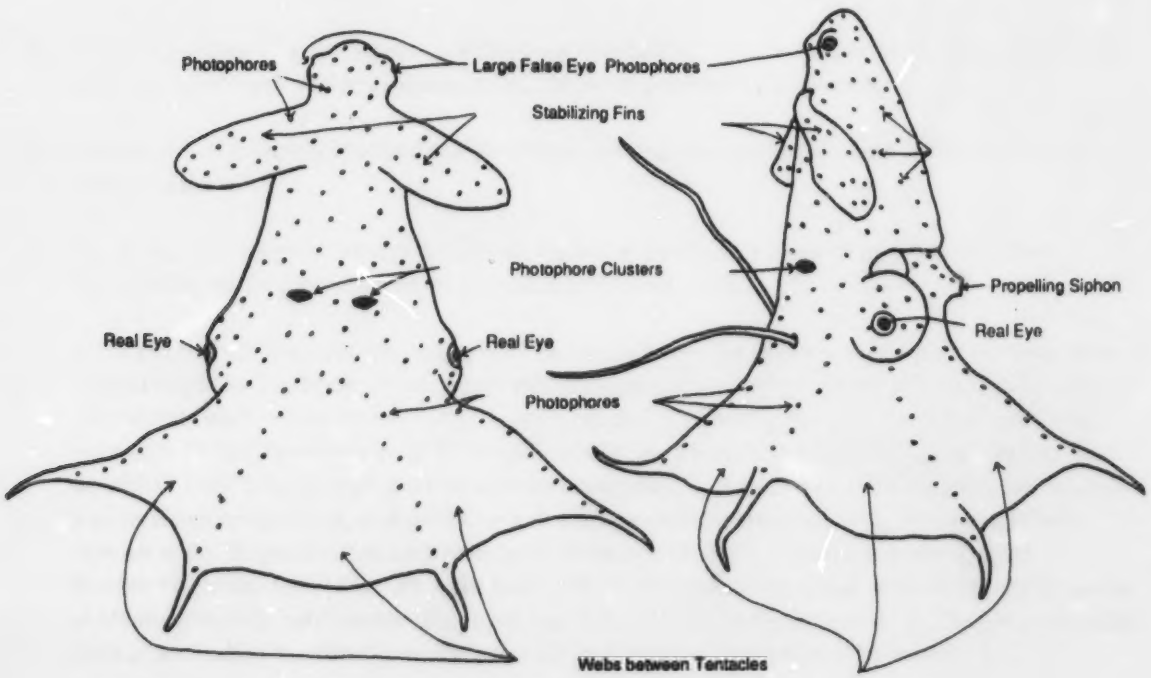
Installation of a Bioluminescent Effect in a Large Model

1. The apparatus for a bioluminescent effect can be installed internally when the body cavity of a model is large enough. The Vampire Squid has three types of bioluminescence: numerous small photophores scattered over its body and tentacles, two distinct photophore "clusters" on its back adjacent to its real eyes and two bright "false eyes" above its stabilizing fins. This squid hangs in the water with its fins uppermost and its webbed tentacles hanging downwards.

2. Remove the fin flaps from the Sculpy model and make two-piece moulds of them (SEE: Roughscale Grenadier—Making a two-piece mould, step 1–11).

3. Make a glove mould of the remaining Sculpy model (SEE: Flapjack Devilfish—Making a small glove mould, method two, page 26) Make the epoxy jacket in three sections for easy removal.

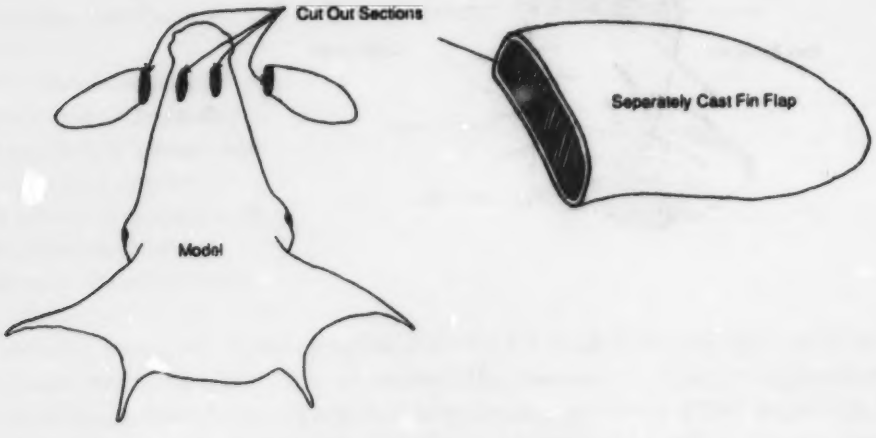
4. Make an epoxy cast of the glove mould in the appropriate colours (SEE: Flapjack Devilfish—Casting a small hollow, epoxy model , steps 1–9 and 12–13). Add opaquing pigments to the final epoxy layers to keep light from shining through the cast from inside the model.



5. Make hollow epoxy casts of the two-piece fin moulds (SEE: Coho Salmon—Casting a hollow model using a rotational moulder , steps 2–9).

6. Cut out the section of the cast epoxy fin that will butt against the model's body when the fin is attached to the model. Cut out the corresponding area on the model's body.

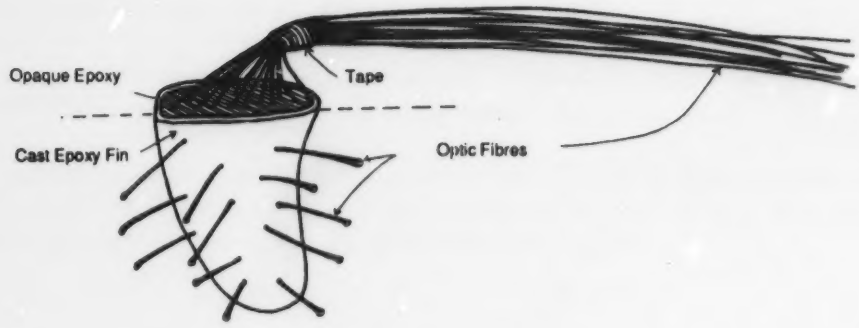
   Drill holes through the fin's surface, in the photophores' locations, with appropriately sized drill bits. Cut acrylic optic fibres, with diameters corresponding to these holes, into 60 cm (24") lengths and thread them through the holes. Leave about 25 mm (1") of fibre protruding from the outside surface of the fin. Run the rest of the fibre length through the cut-out section of the fin. Bundle the fibres where they exit the cut-out section and tie them together with tape.



   Support each fin with its cut-out section horizontal and fill the cavity inside the fin with 5-minute epoxy mixed with an opaquing pigment. Let the epoxy cure. Repeat the procedure with the other fin. Put the fins aside for later attachment to the model.

7. Make and install the "false eyes" photophores by the following process. Drill a 4 mm (1/6") hole inside each "false eye" cavity (located above the fins). Cut enough 45 cm (18") lengths of optic fibre to form a 4 mm (1/6") diameter bundle. Feed the bundle of fibres through an equal length of black heat-shrink tubing. Shrink the tubing tightly around the fibres (be careful not to melt the fibres) to form a cable. Trim the tubing back 1.5 mm (1/16") on one end of the cable so that the fibres protrude slightly. Apply more heat to about 25 mm (1") of this end, until the fibres become flexible. Gently turn over a crook of about 90° approximately 13 mm (1/2") from the end, and hold the cable in this position until it cools and becomes rigid. Feed the crooked end through the hole in the false eye cavity from inside to outside. The 1.5 mm (1/16") uncovered portion of the optic cable sticks out through the hole. The rest of the cable is inside the model.

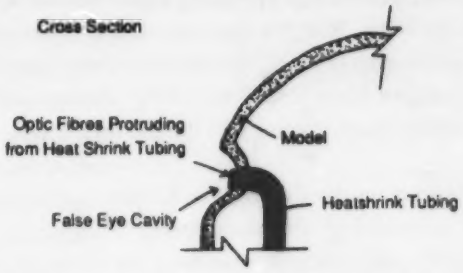
Mix a thick paste of 5-minute epoxy, Aerosil and opaquing pigments. Heavily coat around the cable inside the model with this mixture. Hold the cable in position until the epoxy cures. Make a mixture of 5-minute epoxy and black pigment. Coat around (but not over) the protruding fibres and the surrounding area inside the false eye cavity. Let the epoxy cure. Use a Dremel bit to grind off the ends of the optic fibres flush with the black epoxy. Repeat this procedure for the false eye on the other side.



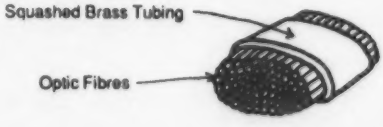
8. To make the photophore "clusters" cut a 13 mm (1/2") long piece of 6 mm (1/4") diameter brass tubing. Using pliers, squash the tubing into an oval shape. Pack the tubing with 19 mm (3/4") long pieces of acrylic optical fibres. The fibres protrude from both ends of the tubing. Inject 5-minute epoxy between the fibres with a syringe. Cover the ends of the fibres with epoxy as well. When the epoxy has thoroughly cured (at least several hours), sand the fibre bundle ends flat and then polish them with a plastic polish.

9. To install the photophore clusters, grind through the epoxy model in the areas where the clusters are located. Make the cluster hole slightly smaller than the optic fibre bundle. Position the optic fibre bundle, inside the model, against these holes with one end of the fibres facing outwards. To hold them in place and seal the join, squash a wad of uncured Sculpy over the bundle on the inside of the model. Support the model with one of the cluster holes facing upwards horizontally. Pour clear 5-minute epoxy into the space above the optic fibre bundle until the impression is full (overflowing slightly) to the level of the model's existing outer surface. Let the epoxy cure. Resupport the model with the other cluster hole horizontal and repeat the procedure.

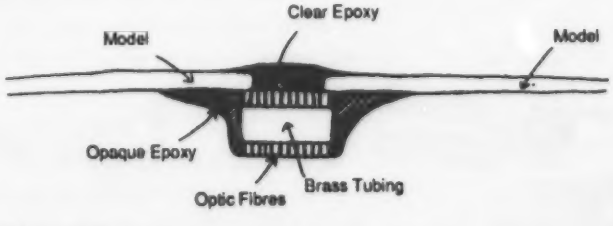
Remove the uncured Sculpy from the inside of the model and thoroughly clean the bundled surfaces. For additional bonding, mix a thick paste of 5-minute epoxy, Aerosil and opaquing pigments and apply it around the optic fibre bundles inside the model. Do not cover the ends of the optic fibres. Scrape, buff and polish the area over and around the clusters to blend the cured epoxy with the rest of the model's outer surface.

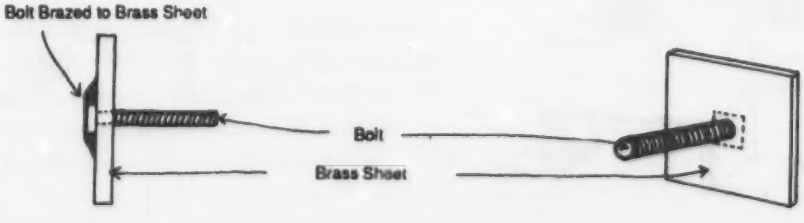


10. One electro-luminescent lamp (E.L. strip) 13 mm by 32 mm (1/2" by 1-1/4") will be used to light each photophore cluster. Brackets need to be fabricated to hold these E.L. strips in place. Drill a hole through the centre of a 13 mm by 13 mm(1/2" by 1/2") square of thin sheet brass. Fit a 19 mm (3/4") bolt through this hole and braze the bolt to the brass square.



Position the brass squares flat against the inside of the model, about 38 mm (1–1/2") below each cluster's optic fibre bundle. Laminate them to the model with 5-minute epoxy overlaid with fibreglass cloth. Be careful not to get epoxy on the bolt threads. Cut out two pieces of brass sheet 13mm by 50 mm (1/2" by 2"). Drill a hole, just big enough to fit over the bolt, in each piece 6 mm (1/4") in from the end. The brass must be heavy enough to hold a bend. Bend the brass strips about halfway along their length at approximately a 130° angle. Lay the prewired E.L. strips over the clusters with the lighting side against the ends of the optic fibres. Fit the brass strips over the bolts. The other end of each brass strip covers an E.L. strip. Secure the brass strips on the bolts with lock washers and nuts. The bends in the brass follow the contour of the inside of the model and the E.L. strips are held in place by the pressure of the brass strips.

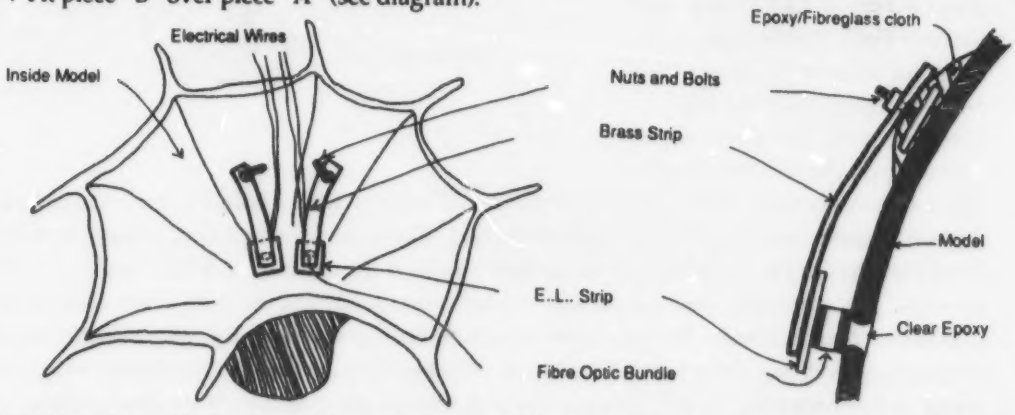




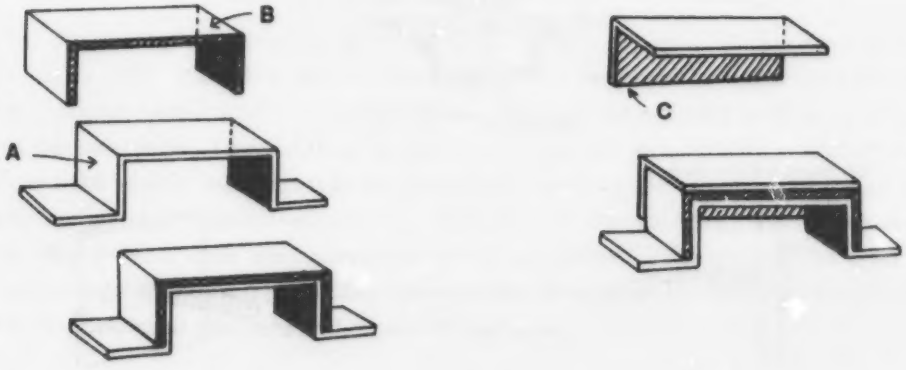
11. Attach the fins, one at a time, to the model. Thread the optic fibres through the holes that were cut into the model's body in step 6. Make a mixture of 5-minute epoxy, Aerosil and pigments to match the model's colour. Carefully apply the epoxy mixture to the edges of the fin and affix the fin to the model's body. Hold it in place until the epoxy cures. Repeat with the other fin. Mix a thick paste of 5-minute epoxy, Aerosil and opaquing pigments and apply a heavy coating, inside the model, where the fins join the body. Remove the tape used to bundle the optic fibres. Thread the bundles of optic fibres through lengths of black heat-shrink tubing (one for each fin). Shrink a small section of the tubing to secure the fibres inside the tubing. Scrape and blend the epoxy on the outside surface around the areas where the fins join the model's body.

12. Additional bracket hardware needs to be fabricated to attach the E.L. strips for the "false eyes" and for the small scattered photophores effects. Two separate light sources need to be installed since the false eyes light up at different times than the other photophores.

13. To make the false eye E.L. strip bracket, cut a strip "A" of sheet brass 82.25 mm long by 13 mm wide (3–1/4" by 1/2"). Cut another piece "B" 57 mm by 13 mm (2–1/4" by 1/2"). Make sharp 90^{0} bends 25 mm (1") from each end of piece "A" and 13 mm (1/2 ") from each end of piece "B". Make a second 90^{0} bend, in the opposite direction from the first bend, 13 mm (1/2 ") from each end of piece "A". Fit piece "B" over piece "A" (see diagram).

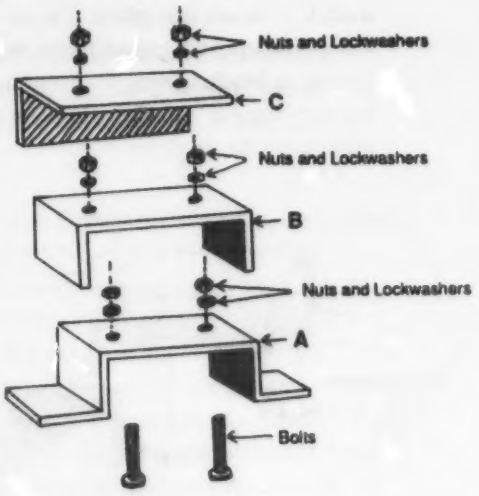


Cut another piece of brass sheet 25 mm by 56 mm (1" by 2-1/4") wide and fold it lengthwise down its center at 90°. Call this piece "C". Fit piece "C" over the other two pieces (see diagram).

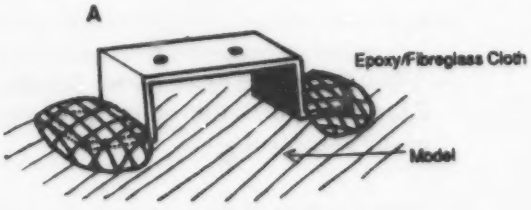


Drill two holes through all three pieces, about 6mm (1/4") from each end. Fit the holes with bolts and nuts (one set of bolts and three sets of nuts and lockwashers).

14. Position piece "A" inside the model, on an area of tentacle web where no photophores are located. Locate it where it can be easily accessed and where the optic cables from the false eyes can easily reach. Place it with its flanges (the second 90° bent ends) against the model and the bolt holes away from the model. Mix a thick paste of 5-minute epoxy and Aerosil and coat over the flanges and the area immediately surrounding them. Reinforce the attachment by embedding pieces of fibreglass cloth into the epoxy over the flanges.

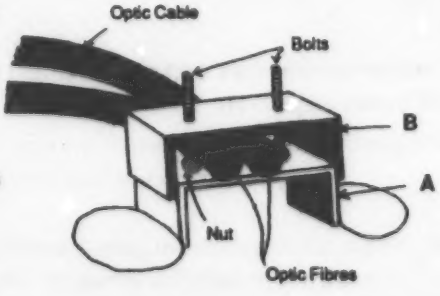


15. Fit the bolts through the holes in piece "A" with the threaded ends pointing outwards away from the model. Tightly secure them with lockwashers and the first set of nuts. Fit piece "B" loosely over the bolts. Sandwich the optic cables from the false eyes between pieces "A" & "B". Fit a second set of lockwashers and nuts onto the bolts and tighten them so that the cables are securely clamped between pieces "A" & "B". Cut the cables off flush with the edge of this clamp.

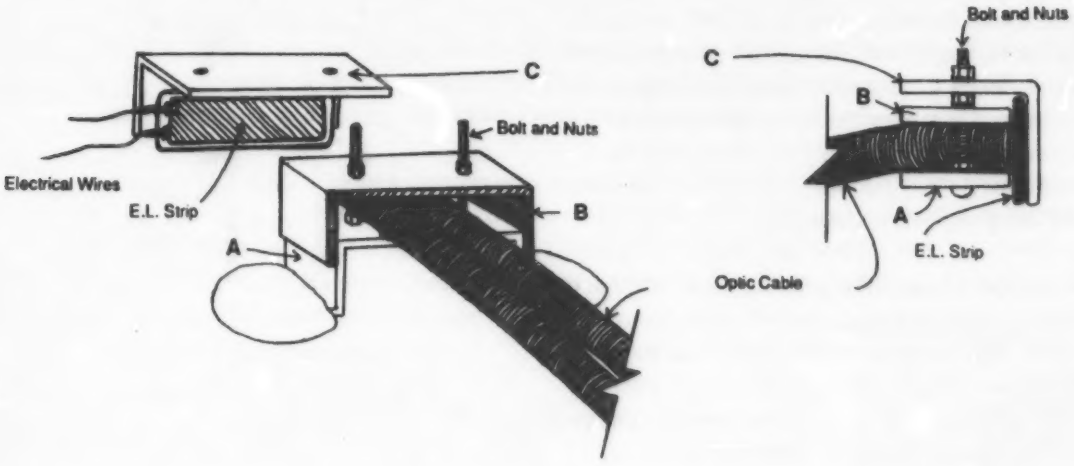


16. Lay a prewired E.L. strip over the exposed ends of the clamped optic cables with its lighting surface against the optic fibres. Position piece "C" with its holes over the bolts and with its bent side covering the E.L. strip. Fit the last set of lockwashers and nuts onto the bolts and tighten them so that piece "C" securely holds the E.L. strip in place against the optic fibres.

17. Drill holes, with an appropriately sized drill bit, in the locations of the small photophores scattered over the squid's body and tentacles. Cut optic fibres into lengths 60–90 cm (2–3') long. Starting at the end of the model with fins, thread a fibre through each photophore hole. Leave about 25–38 mm (1–1 1/2") of fibre protruding on the outside of the model. Bundle groups of the fibres together, on the



inside, as you work and thread them through lengths of black heat-shrink tubing to form cables. Heat a small section of each tube to shrink it around the fibres and secure them inside it. Mix 5-minute epoxy, Aerosil and opaquing pigments and apply around each fibre, on the inside of the model, to secure it in place. Let the epoxy cure. Continue threading the fibres, bundling them into cables and epoxying them to the model until all the holes have been filled. Make another brass mounting bracket using the same method as for the false eye photophores (steps 13–16). Make this bracket larger to accommodate the many optic cables from the scattered photophores including those from the fin flaps.



Attach the bracket to the model. Bolt the bracket pieces together to clamp the optic cables and an E.L. strip in place. Clip off the fibres, protruding out through the model's surface, flush with the model's outer surface.

18. Make a pattern of the opening to the inside of the model at the bottom of the tentacles' webs. Use this pattern to cut out a piece of heavy, light-tight fabric (such as "Duvetyne" - used for theatre special effects and sets). Fit the fabric into the model's opening and use 5-minute epoxy to attach it to the model. Leave a flap opening unattached for accessing the E.L. strips. For fastening and light-sealing the flap closed, attach pieces of Velcro to the fabric with thread and to the model with epoxy.

19. Grind out the true eyes' sockets. Make and install eyes. (SEE: Roughscale Grenadier—Making eyes with lenses, steps 1–15).

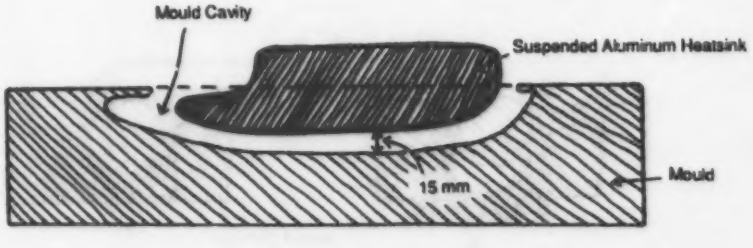
FLAT SEA CUCUMBER *(Paelopatides confundens)*

Casting a PVC Model

1. **HEALTH HAZARD WARNING: PVC should only be heated in areas with sufficient local exhaust ventilation or a window exhaust fan and always wear an approved organic vapour respirator during the curing process. An oven used to cook PVC must have a fan exhaust channelled out of the work area.**

2. PVC stands for the Polyvinylchloride group of plastics. They cure by heat unlike epoxy or polyester resins which cure by the addition of catalytic hardeners. Some models cast in PVCs can be beautifully natural and soft in appearance with realistic translucent colours. Layers can be quickly built up over each other. PVCs vary in hardness (durometer) from very hard to very soft and jellylike. Models cast in PVCs of lower durometer will be flexible which is an advantage for demolding complicated moulds. Flexibility is also useful for manipulating the models into different attitudes during installation into exhibits. Complete curing is critical as inadequately cured PVC can break down over time. Experimentation is necessary to establish the correct cooking times for each individual mould. This will vary with volume and thickness and configuration of the mould.

3. Make a one-piece mould of the sculpted Sculpy Flat Sea Cucumber model (See: Deep Sea Skate—making a one-piece mould, step 1–12). The mould is approximately 120 mm long by 55 mm wide by 20mm deep (4" by 2" by 3/4") with a volume of approximately 100 ml. During research and development for this model, the mould was preheated (20–25 minutes) to approximately 176°C (350°F). PVC was poured into the mould and cooked for 3 minutes at 350°F. The results were poor with incomplete clarifying of the material and with checks forming on the exposed surface at the mould opening. The PVC manufacturer (Q.C.M.) was consulted and it was recommended to not try to achieve complete cooking of PVC thicknesses of over 10–15 mm.
To overcome this limitation, a heatsink was sculpted from 37 mm aluminum bar stock and suspended in the mould cavity to displace some of the volume in the mould so that there is only a maximum thickness of 15 mm at any point in the mould cavity.



The aluminum of the heatsink facilitates the movement of heat into and out of the curing PVC. Cooking experiments were performed to arrive at a technique to produce a model that was cooked completely through with minimal discolouring.

4. The colouration of the Flat Sea Cucumber model is achieved during the casting of the model. Make a colour sketch, after consulting with the curator and using reference material, to work out the colour lay-ups. Mix the series of colours needed by adding PVC compatible pigments to clear PVC. After mixing the PVC, remove the air from it in a vacuum chamber. Store uncured PVC in covered containers to reduce absorption of moisture from the air.

5. Test the colours of the PVC by putting some in a metal dish and curing them with a heat gun. Do not overheat each layer as this may cause cracking— just heat the PVC to the "jell" point. Set the mould on a warm hot plate while doing the lay-ups to keep the mould at a temperature that will jell the P.V.C. The temperature of the hot plate will vary according to the thickness and overall size of the silicone rubber mould. Don't leave a laid up mould uncured for long periods of time, such as overnight, as the plasticiser may separate out of the PVC. It is better to lay up the colours, fill the mould with the base colour and cook the model all in one day.

6. Begin the lay-up of the mould in the head area. Heat the mould and apply thin layers of coloured PVC, jelling them with a heat gun between layers. Work along the sides and into the middle of the mould. It is best to layer more uncured material over the previously cured PVC where more heat will be applied. This avoids over-curing of the preceding layers.

7. Preheat the aluminum heatsink in a convection oven at 196° C (385° F). Apply a layer of the base colour PVC all over the inside of the mould on top of the previously applied and jelled PVC layers, and put the mould into the oven at 196° C (385° F) for a few minutes to jell the PVC. Estimate the amount of PVC needed to fill the cavity of the mould with the heatsink in place. Pour one half of this amount of the base colour PVC into the mould. Carefully, avoiding creating air bubbles, slip the heatsink into position inside the mould. Fill the remaining space in the mould with more base colour PVC.

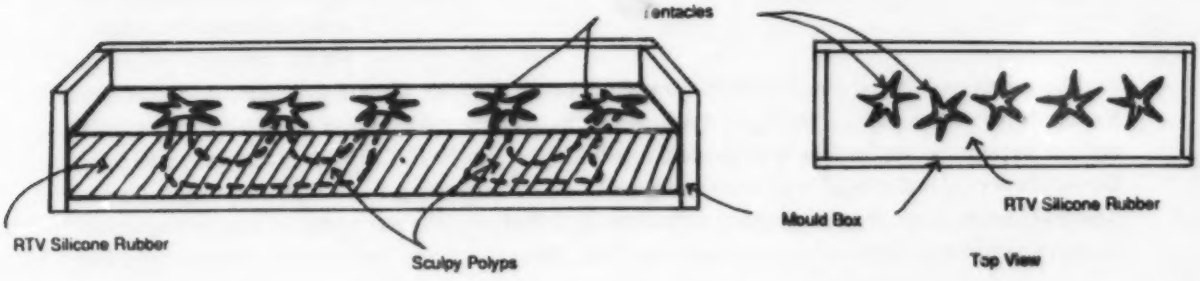
8. Cook the PVC and heatsink-filled mould in a convection oven at 196° C (385° F) for 18 minutes.

9. Let the mould cool. It can be put in a fridge or freezer to drop the temperature more quickly. Do not take the model from the mould until it is completely cooled, then remove the heatsink and the model. Imperfections can be repaired with a mixture of 45% paraffin wax, 45% beeswax and 10% carnauba wax tinted with oil paints.

DEEP SEA WHIP (*Balticina california*)

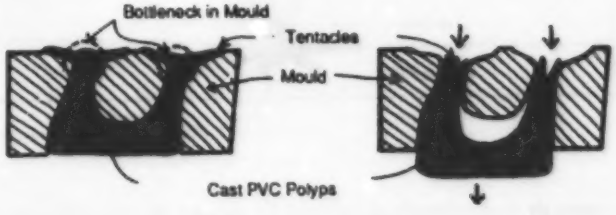
Assembling a PVC Model from Separately Cast Pieces

1. The Deep Sea Whip is a organism that is made up of many individual animals, called polyps, living collectively. The colony is arranged along a central stalk with the filter feeding polyps projecting outwards from it. If one mould was made of an entire Sculpy Deep Sea Whip model, the complexity created by the many projection angles of the polyps would make the mould very difficult to cast. It would also be very difficult to remove from the mould. The solution to this problem is to sculpt individual polyps (or groups of three or four polyps) of various sizes and then make separate moulds of them. These moulds can then be cast and the cast polyps assembled into a complete Deep Sea Whip model. One advantage to making a model in this way, by assembling its separate components, is that only a few moulds are needed to produce a large number of component parts. This saves both sculpting time and mould-making materials.



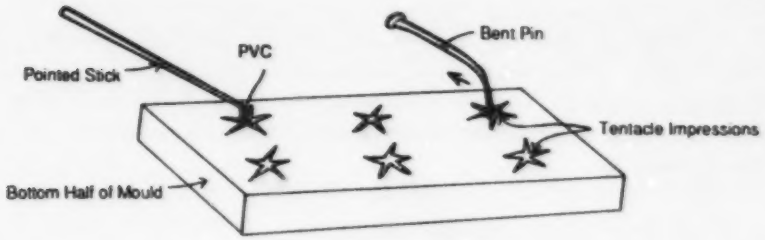
2. Sculpt several polyps and groups of polyps in Sculpy. Make two-piece moulds of them (SEE: Roughscale Grenadier—Making a two piece mould, steps 1–13). Several polyps can be moulded in one mould box. Arrange the models on the bottom of the mould box with their star-like tentacles uppermost and level in the same plain. Fill the mould box with RTV silicone rubber up to the bottom of the tentacles. Leave the tentacles exposed on the surface of the rubber. Let the rubber cure.

   Coat the exposed surface of the cured rubber with Vaseline/toluene release agent. Pour 6 mm (1/4") of rubber into the mould box to form the second half of the mould. Let it cure. Remove the mould box and take out the Sculpy polyps.
   Thoroughly clean the mould in preparation for casting.



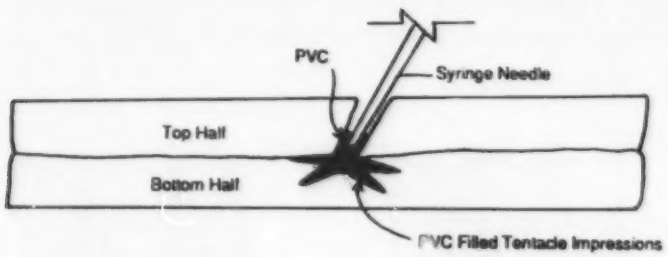
3. The cast polyps will be removed by grasping the base of the polyps and pulling them out of the mould. There is a "bottleneck" formed under the tentacles. If the polyps are cast in a rigid material, the delicate tentacles could break off, or damage the mould, during their removal. PVC of low durometer (hardness) will be flexible enough for the tentacles to bend while being pulled through the mould. For this reason it is appropriate to cast this model in PVC (SEE: Flat Sea Cucumber— Casting a PVC model, step 1–5).

4. Make a colour sketch from reference sources and in consultation with the curator. Mix PVC and PVC compatible pigments to achieve the desired colours. Evacuate the air from the PVC in a vacuum chamber. Use a pointed object, such as a wooden stir-stick sharpened at one end, to dab a little bit of the dark red PVC at the centre of each star of tentacles in the polyp moulds. With a bent pin draw out the PVC along each tentacle. Add more PVC wherever needed to fill the tentacle impressions. Use an opaque red PVC so that the thin tentacles will be more visible.



5. Put the two halves of the moulds together. Place clamps around the perimeter of the mould to hold the two halves of the mould together and to prevent leakage of the PVC. Use a syringe to inject a lighter, translucent red PVC into the stems of the polyps. Fill the syringe by pulling out the plunger completely and pouring the PVC into the reservoir chamber. Carefully replace the plunger. With the needle pointed up, squeeze the liquid upwards with the plunger and let any air bubbles rise to the surface and out through the needle. This helps to avoid introducing air into the PVC. Place the syringe needle into the very bottom of each mould impression and apply pressure to the plunger while slowly drawing the needle upwards. This will avoid trapping air bubbles at the bottom of the polyp stems. Leave enough room on top of each stem cavity to inject some darker red PVC. This gives the polyps a realistic gradation of colour.

6. Preheat a convection oven to 176°C (350°F). Cook the PVC filled moulds for 25 minutes. If the oven is not preheated to 176°C (350°F) when the moulds are put into it, the polyps in the centre of the mould may not reach the temperature necessary to cure the PVC completely.



7. Place the moulds in a freezer to cool to speed up production. In approximately 15 minutes the mould will reach room temperature. Remove the clamps and separate the two halves of the mould. Bend the half of the mould with the cast inside to create a crack between the top edge of the cast and the mould. Apply a drop of WD40 penetrating lubricant into this crack. This lubricant helps to release the cast from the mould, without breakage of the delicate tentacles, during demolding. Remove the cast PVC polyps from the mould. Because a small amount of PVC squeezes out between the two halves of the mould most of the polyps will have a PVC membrane between their tentacles. Carefully remove this membrane.

8. Make the shaft of the sea whip by forming a 7.9 mm (5/16") diameter aluminum rod with a rasp. Bend the rod to the desired curve. Apply a white-tinted PVC base coating to cover the silvery appearance of the aluminum rod and to give the shaft a realistic inner glow. Mix yellow-orange

PVC for the stem. Add Aerosil fillers to this PVC mix to thicken it. This thicker PVC is easier to control when applying it to the rod with a brush. Brush a coating of the yellow-orange PVC over white PVC on the rod. Use a heat gun to cure the PVC. Moving the stem quickly at different angles during curing helps to control the flow of the PVC.

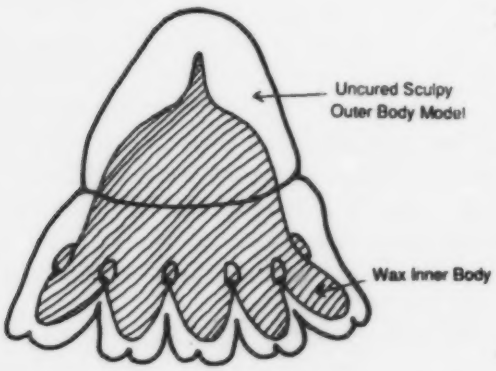
9. Glue the polyps to the PVC-coated shaft with Elmer's Clear Cement. When gluing the polyps onto the shaft, try to arrange them as naturally as possible. Be careful not to repeat angles and spacing. Some polyps may need to be cut to different lengths and reglued at different angles.

DEEP SEA JELLYFISH *(Periphylla hyacinthina)*

Making and Casting Moulds for a Semi-Transparent, Multi-layer Model

1. Many marine specimens have transparent or translucent portions to their bodies that reveal some of their internal structures. The Deep Sea Jellyfish has a transparent outer body ("jelly" layer) over a multi-coloured inner body.

2. Sculpt the model in two layers. Sculpt the first inner body model in casting wax. Apply a layer of Sculpy over the wax model. This Sculpy layer is the "jelly" layer so it must be the thickness of that outer body. Be careful not to trap air pockets between the Sculpy and the wax. Sculpt the shape of the outer body model onto the Sculpy layer. DO NOT bake this Sculpy layer because the wax model inside it will melt.



3. Two moulds have to be made: (1) the wax inner body model, and (2) the Sculpy outer body model. It must be possible to register the *model* from the mould of the inner body to fit inside the *mould* of the outer body. The outer body is then cast around the inner body model. This is accomplished by creating a *base mould* common to both the other moulds.

4. Invert the combined Sculpy and wax model and support it in a cup padded with soft foam. Handle it with great care as an unbaked Sculpy model is very delicate. The bottom of the model is now uppermost. The bottom of the wax inner body model can be seen surrounded by the Sculpy outer body model.

   Cover this exposed wax by building up a Sculpy dam about 6 mm (1/4") thick. Leave the Sculpy model uncovered.

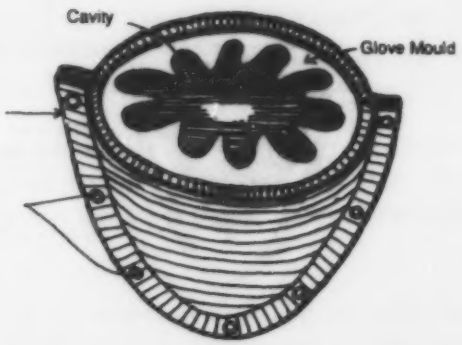
5. Make a freeform glove mould of the Sculpy outer body model (See: Making a small glove mould—method two: freeform mould, step 3–13). This is the (2) mould of the outer body Sculpy model.

6. Turn the mould over, encased in its epoxy jacket, and support it with its bottom uppermost. Remove the uncured Sculpy dam that was built over the bottom of the wax model in Step 4. This creates a cavity with the wax model exposed at the bottom. The underside of the glove mould forms the cavity's sides.
   Paint the exposed surfaces of the silicone rubber glove mould with Vaseline/toluene release agent. Pour a mix of Dow Corning RTV "E" silicone rubber into the cavity over the wax model. Fill the cavity and then continue pouring in the rubber, overflowing the cavity, to cover the exposed mould out to the rim of the epoxy jacket. Let the rubber cure. This forms a separate, solid silicone rubber *base mould* that is the bottom piece of the outer body's glove mould (see diagram). This base mould

will also be the bottom piece of the inner body's mould. Therefore the position of the cast inner body model will be perfectly registered to that of the outer body mould when the outer body model is cast.

7. Remove the silicone rubber base mould and the epoxy jacket from the glove mould. Place the model with its bottom down still encased in the silicone rubber glove mould, in a glass dish. Support it, raised slightly, above the dish. Place this in an oven at 149°C (300°F) for about 20 minutes until all of the wax model has melted and run out of the mould into the glass dish. This exposes the cavity, the size and shape of the melted wax model, inside the Sculpy outer body model. The glove mould supports the Sculpy outer body shell. For further support, reassemble the epoxy jacket around the glove mould. The Sculpy is now hard because it baked while the wax model was being melted out.

8. Paint Vaseline/toluene release on the exposed cavity inside of the cured Sculpy outer body model (otherwise the epoxy will adhere to cured Sculpy). Apply a coating of Nu-Clear epoxy, slightly thickened with Aerosil, to this exposed Sculpy surface of the outer body model. Let the epoxy cure. Mix enough unthickened Nu-Clear to fill the Sculpy model's inside cavity. Pour it into the cavity. Cut a hole through the center of the silicone rubber base mould and insert a screw into the hole with the threaded end protruding on the inner side of the base mould. Close the mould by fitting the base mould in place. The threaded end of the screw is pushed into the uncured epoxy. Allow the epoxy to cure. This epoxy forms a cast plug of the cavity inside the Sculpy outer body model. The epoxy plug is the shape of the wax inner body model that was melted out.



9. Clean the epoxy plug and repair any imperfections (filling cracks, sanding the surface, etc.).

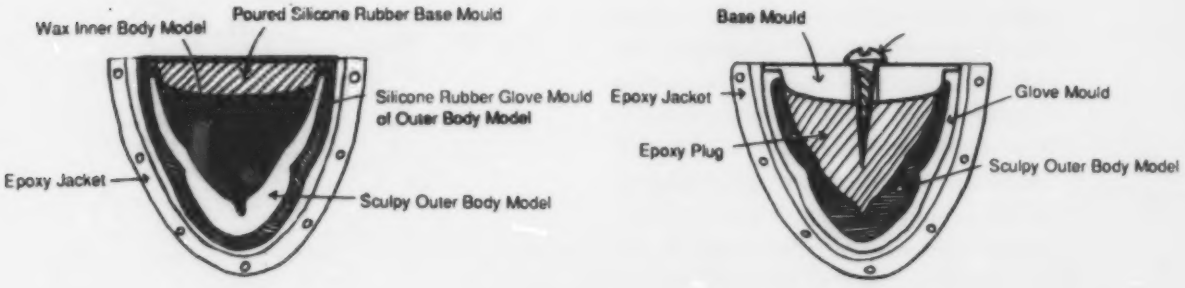
10. Support the plug right side up with the base mould on the bottom. Apply Vaseline/toluene release to the exposed rubber areas of the base mould. Construct a cone from a waxed paper cup, with the same circumference at its bottom edge as that of the base mould. The cone should be open at the top and bottom. Fit it over the epoxy model and base mould. Seal, with uncured Sculpy, around the cone's bottom edge where it meets the base mould.

11. Mix and remove the air from silicone rubber. Slowly fill up the cone to about 13 mm (1/2") over the top of the epoxy model. Let the rubber cure. Remove the cone and take out the epoxy plug. This mould is the inner body mould of the wax model. Remove the epoxy plug from the base mould by pulling the screw through the hole in the base mould. The silicone rubber is flexible enough to do this without damaging the base mould. The plug and screw can be discarded because they will not be used again.

12. Clean and prepare the moulds for casting the complete combination model. There are three components: a silicone rubber glove mould of the outer body with a rigid epoxy jacket, a silicone rubber poured mould of the inner body, and a silicone rubber base mould common to the first two moulds.

13. Produce a multilayered colour sketch, from research and consultation with the curator, for casting the jellyfish in epoxy. (See: Roughscale Grenadier—Casting a solid epoxy model in a two-piece mould: multi-colour lay-up, step 1). The lay-ups will be tinted with Hacol Transparent Dyes.

14. Mix 3 cc of Sun-Cure epoxy and #1 colour (#l colour: four drops mandarin dye plus two drops yellow dye). Thicken the epoxy slightly with a small amount of Aerosil filler. Coat the inner-body mould with #1 coloured epoxy mix then use a heat gun to break up air bubbles. Let it cure. Mix another 3 cc of Sun-Cure epoxy, Aerosil and #2 colour (#2 colour: four drops yellow dye). Make a



third epoxy mix using tint colour #3. (#3 colour: three drops rose dye plus 10 drops red dye). Thicken this mix a bit more than the first and second mixes so that the epoxy will stay where it is applied in the desired pattern. Do not heat this layer (with the heat gun) to further avoid having the epoxy flow out of position. Apply the epoxy to the mould and let it cure. Make a fourth epoxy mix, of the same thicker consistency as the preceding lay-up, tinted colour #4 (#4 colour: l0 drops Red dye plus l0 drops green dye plus l0 drops mandarin dye) Apply it to the mould, without heating it, and let it cure. Tint a fifth epoxy mix with #5 colour (#5 colour: 20 drops red dye) and apply it in the same manner as the third and fourth layers.

15. After the coloured layers have cured, mix 75 cc of untinted Sun-Cure epoxy and fill the mould. Brush the epoxy up into the lower edges. Fit a small bolt through the hole in the base mould with the *head protruding on the inside* of the mould about 13 mm (1/2") and the threads *outside* the mould. Crimp the threads at the point where the end of the bolt emerges on the outside of the base mould. model will be perfectly registered to that of the outer body mould when the outer body model is cast.

    Thread a nut onto the bolt up to the crimp (it will not go past the crimp mark). With the bolt attached, fit the base mould onto the inner body mould (which is filled with uncured epoxy). Seal around the seam between the mould pieces with uncured Sculpy to prevent the epoxy leaking out. Turn the assembled mould over and support it, base side down, to cure.

When the epoxy model has cured, remove the nut from the bolt and remove the base mould. Then remove the epoxy model. Clean up the mould (cast edges, etc.). Reattach the epoxy cast to the base mould using the nut and the bolt. The bolt's head is now embedded in the epoxy model. Tighten the nut to the crimp mark.

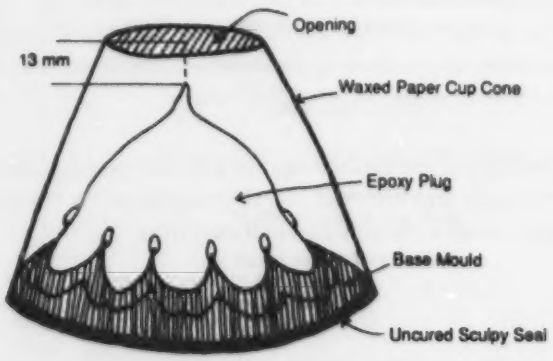
16. Apply several layers of clear Sun-Cure epoxy to the outer body mould. This can be done while the colour layers are being built up in the inner body mould. Build up the epoxy until the whole surface has been covered. Heat the epoxy with a heat gun during lay-ups to break surface air bubbles.

17. Mix about 90 cc of Sun-Cure epoxy. Let it stand in a wide-mouthed container to create a large surface area for the air bubbles to rise to and break. Let the epoxy stand about one hour. Work over its surface with a heat gun to break up the bubbles.

18. Very slowly and carefully pour the epoxy into the outer body mould. Warm the surface of the epoxy again with a heat gun to release as many air bubbles as possible. Very carefully insert the cast inner body model, attached to the base mould, into the epoxy in the outer body mould fitting the base mould into place. Seal the seam between the mould pieces with uncured Sculpy to prevent leakage of the epoxy. Support the assembled moulds, bottom side down, and let the epoxy cure.

19. Remove the fused model from the mould. Support the model upside down and grind out a hollow about 50 mm (2") in circumference around the bolt. Cut off the bolt flush to the model. With Aerosil, heavily fill and tint the epoxy white. Pour this epoxy into the hollow, until it overflows out over its edge a bit. Let the epoxy cure.

20. Clean up the surface of the model by scraping and buffing. Fill any voids caused by air bubbles with Sun-Cure epoxy injected with a syringe and needle. Coat the outside and the underside of the model with clear Sun-Cure epoxy to clarify the "jelly" layer. After the epoxy is thoroughly cured, airbrush the model very lightly with matte acrylic medium to reduce the shine on its surface.



DEEP SEA JELLYFISH (*Periphylla hyacinthina*)

Forming Acrylic Tentacles

1. The translucent tentacles can be fabricated using acrylic rod. Cut 3 mm (1/8") diameter acrylic rod into lengths two to three times the finished length of a tentacle. Hold the rod, by its ends, with both hands. Gently heat the centre 50–75 mm (2–3") of the rod by rotating it over hot air from a heat gun. When this middle section is soft and rubbery, pull the ends apart very gently to stretch and taper the centre section. Great care and considerable practice are required to produce an evenly tapered piece of the desired length.

Cut the stretched strand at its centre to make two separate tapered lengths. Cut, file and sand the tentacles to their finished lengths.

2. Heat a piece of metal pipe with a heat gun. Shape a tentacle into a sinuous configuration by rolling a section of the tentacle against the warm surface of the pipe until it is plastic enough to bend. Hold the tentacle in any desired attitude until it cools and becomes rigid again. Continue forming the tentacle, section by section, until the whole tentacle has been shaped. Care must be taken during the warming process because overheating the stretched acrylic will cause it to shrink, shorten and thicken as the rod tries to return to its original shape.

3. Determine the positions of the tentacles on the jellyfish model. Drill 6 mm (1/4") deep holes, with diameters slightly larger than the thick end of the tentacles, in the appropriate places on the model. Use 5-minute epoxy to affix the tentacles in these holes.

APPENDIX:
Materials, Sources and Suppliers

Acetate Sheets
Artist, Graphic Arts or Printing Supply stores

Acrylic Medium
Artist or Paint Supply stores

Acrylic Optic Fibres
(For small quantities of Plastic Optic Fibres)
Efston Science Inc.
3350 Dufferin Street,
Toronto, Ontario
Canada M6A 3A4
Telephone (416) 787-4581 FAX (416) 787-5140

(Cheaper but must be volume sales)
ESCA 2 Acrylic Fibres
Argo Plastics
(Affiliate - Mitsubishi Rayon Company Ltd. Japan)
6820 E. Washington Blv.
Los Angeles, California
90040 USA
Telephone (213) 724-3090

Acrylic Paints
Artist Supply stores

Acrylic Rod
Plastics Supply store

Aerosil (also called Cabosil)
This is fumed silica - an inert filler for organic resins
Plastic or Fibreglass (Marine) Supply stores

Aluminum Bar Stock
Metal or Welding Supply stores

Aluminum Lining Bronze (Silver Coloured Powder)
Artist Supply stores

Aluminum Rod
Metal or Welding Supply stores

Automotive differential gears - Auto Wreckers

Brass Tubing
Craft Supply stores

Cyanoacrylate Glue (such as Krazy Glue, Locktite etc.)
Plastic Supply, Hardware, Stationary or Craft Supply stores

Damar Varnish
Artist Supply stores

Dental Tools
Dental Supply stores

Dremel Tool (also see: Foredom Tool)
(Hand held flexible shaft electric tool with multi accessory bits for cutting, drilling, buffing, grinding, sanding etc.)
Available from Crafts, Jewelery or Woodcarving Supply stores or
Dremel - Division of Emerson Electric Company,
Racine, Wisconsin
53406 USA

Duvetyne Fabric
Theatrical Supply stores

Williams F. White Ltd.
555 Brookabank Ave.
North Vancouver B.C.
Canada V7J 3S5
Telephone (604) 983-5300

Rosco
1271 Denison Street #66,
Markham, Ontario
Canada L3R 4B5
Telephone (416) 475-1400 FAX (416) 475-3351

Dyes
Hacol Colours- transparent dyes for resins
Hastings Plastic Company
Santa Monica, California

Dyes (Various Light-resistant Graphic Arts)
Artist or Graphic Arts Supply stores

E.L. Strips (see: Electroluminescent Lights)

Electrical Conduit Joining Sleeve
Building or Electrical Supply stores

Electroluminescent Lights and Inverter Capsules
Luminescent Systems Inc.
Lebanon, New Hampshire
03766 USA
Telephone (603) 448-3444

Elmers Clear Cement
Hardware, Craft or Building Supply stores

Epoxy
"Open Ocean models were made using three formulations of epoxy: Nu-Clear (2 hour cure) Sun-Cure (12 hour cure) and 5 Cure (5 minute cure) available from:
Industrial Formulators of Canada Ltd.
3824 William Street,
Burnaby, B.C.
V5C 3H9
Telephone (604) 294-6315

Fibre Optics (see: Acrylic Optic Fibres)

Fibreglass Cloth and Mat
Plastic or Marine Supply stores

Flo-out Surface Tension Breaker
H. Behlen and Bro.
Amsterdam N.Y.
12010 USA
or
Automotive or Industrial Painting Supply stores

Fomecor Graphics Arts Board
by Monsanto - Graphic Art or Plastic Products supply stores

Foredom Tool (also see: Dremel Tool)
(Hand-held flexible shaft electric tool with multi accessory bits for cutting, drilling, buffing, grinding, sanding etc.)

Available from Crafts, Jewelery or Woodcarving Supply stores or
The Foredom Electric Company,
Bethel Conn.
06801 USA

Frekote 700 Mold Release Agent
Frekote Inc.
(subsidiary of Dexter Corp. - Hysol Division)
170 Spanish River Blvd. W.
Boca Raton, Florida
33431 USA

Grumbacher's Oil Paint Resin
Artist Supply stores

Heat Gun
Electronics Supply stores

Heat-Shrink Tubing
Electronics Supply stores

Heated Roller
United Silicone Canada Inc.
150 Milner Ave, Unit 11,
Scarborough, Ontario
Canada M1S 3R3
Telephone (416) 299-3888

Hot Stamping Foil
United Silicone Canada Inc.
150 Milner Ave, Unit 11,
Scarborough, Ontario
Canada M1S 3R3
Telephone (416) 299-3888

Iridescent Powders
Small orders of Merlin Pearl Powders-
Magic Pearl Corp. (Herbert Lewis Company)
P.O. Box 135
Needham, Mass.
02192 USA
(617) 449-7724

Lacquer Thinner
Paint Supply stores

Litho Aluminum
Recycled from Publishing companies after being used as printing plates

Microspheres
These are inert fillers for organic resins
Plastic or Marine Supply stores

Mold Board
Diamond Supply Inc. (Only known supplier)
200 Dalton Ave 28205
P.O. Box 5115
Charlotte, N. Carolina 28225
Telephone 1-800-438-4139

Oil Paints
Artist Supply stores

Optic Fibres (see: Acrylic Optic Fibres)

Oven (Vented Convection)
Blue M Electric Company
Blue Island, Illinois
USA

PVC
Q.C.M. Company
Kent, Washington
Telephone (206) 872-8877

Pigments
Pigments that are especially formulated for PVC, Polyester and Epoxy Resins are available through Plastic or (some) Paint Supply stores or

Q.C.M. Company
Kent, Washington
USA
Telephone (206) 872-8877

Mohawk Universal Colours
Mohawk Finishing Products
Amsterdam N.Y. 12010 or
Atlanta Gerogia
Dallas Texas
Monteral Que. Canada

Dry Powder Pigments
Plaster/Concrete Supply stores

Plastic Optic Fibres (see: Acrylic Optic Fibres)

Plastic Wrap (such as Stretch and Seal or Saran Wrap)
Grocery stores

Plexiglas (Brand Name of Sheet Acrylic)
Plastic Supply stores

RTV Silicone Rubber (see: Silicone Rubber)

RTV Silicone Rubber Thinner
Dow Corning 200 Dielectric Fluid
Dow Corning Canada Inc.
6747 Campobello Road,
Mississauga, Ontario,
Canada, L5N 2M1

Release Agents (see: Frekote 700 or Toluene/Vaseline)

Rotational Molder Components
Bearings, sprockets etc.- Industrial Supply stores

Scalpels and Scalpel Blades
Medical or Surgical Supply stores

Sculpy
Polyform Products Company
P.O. Box 2119 9420 W. Byron St.
Schiller Park, Illinois
60176 USA
Telephone numbers/ Plant - (312) 678-5240/ Sales - (312) 678-4830

Silicone Rubber (RTV)
(Two-part RTV (Room Temperature Vulcanizing) Silicone Rubber)

Silastic® "E" and Silastic® "J"
(®registered trade mark of Dow Corning Corp.)
Dow Corning Canada Inc.
6747 Campobello Road,
Mississauga, Ontario,
Canada, L5N 2M1

RTV 615 (Clear)
General Electric
Silicone Products Division
Waterford, New York, New York 12188 USA
Telephone (518) 237-3330

Silver Coloured Powder (see: Aluminum Lining Bronze)

Styrofoam
Building Supply stores (Styrofoam SM rigid sheet insulation) or Plastic Supply stores

Surface Tension Breaker (see: Flo-out)

Syringes and Needles
Medical or Surgical Supply stores

Tiny Screws, Nuts and Bolts etc.
Craft or Model Making Supply stores

Toluene
Paint or Plastic Supply stores

Toluene/Vaseline Release Agent
One part melted vaseline to ten parts toluene solvent thoroughly combined.

Vacuum Chamber
A container from which air can be safely evacuated to -1 atmosphere using a vacuum pump. Consult listings in the telephone Yellow Pages under Vacuum Equipment and Systems.

Vacuum Former
Vacuum Former Manufacturing Companies

Velcro
Sewing Supply stores

Vinyl - Calendered, translucent or black
Graphic Arts, Printing or Sign Making Supply stores

Vinyl Sealer
Paint Supply stores

WD40 (penetrating lubricant)
Hardware or Automotive Supply stores

Wax
Dental Wax - Dental Supply stores
Paraffin Wax - Grocery or Craft Supply stores
Beeswax - Artist or Craft Supply stores
Carnauba Wax - Artist or Craft Supply stores
Casting Wax - Jewelery Manufacturing Supply stores

Wood Burning Tool
Craft Supply stores

Wood Clamps
Building or Woodworking Supply stores

GLOSSARY

Aerosil: A fumed silica, an inert filler for organic resins (also called Cabosil)

Aluminum lining bronze: a silver-coloured powder that can be used as a pigment

Bridal veil mat: a fine unwoven felted mat of glass fibres that can be embedded in resins for strength

Cast: to coat or fill a mould with casting material such as epoxy resin and then remove the object when it has cured

Calendered vinyl: vinyl worked into sheets of uniform thickness by passing it through a series of heated and cooled rollers

Cure: to change the physical properties of a material (usually from liquid to solid) by a chemical reaction through application of heat and catalysts, alone or in combination

Curing time: the time it takes for thermosetting plastics to be properly cured

Dremel tool: a hand-held, flexible shaft, electric tool with accessory bits for cutting, drilling, buffing, grinding, sanding, etc.. (Foredom is another brand name)

Duvetyne fabric: a black, closed weave fabric used in theatrical staging

E.L. Strip: an electro-luminescent lamp comprised of a very thin strip laminated with plastic which glows when an electric current passes through it. The strip is used to iluminate instrument panels in aviation and electronics.

Epoxy: a two-part thermosetting plastic resin containing epoxides

Fibre optics: a threadlike filament of glass or plastic used to transmit light by total internal reflection

Fibreglass cloth and mat: filaments of glass woven into cloth or felted into mats which can be embedded into plastic resins to increase their strength.

Filler: a material, usually inert, that is added to a mixture to modify its physical characteristics (e.g. make it thicker or opaque) or reduce the amount of other ingredients used

Fish-eyeing: a condition occurring when the surface tension in a thin coating of liquid causes it to break up into blobs.

Flo-out Surface Tension Breaker: a chemical additive that reduces the tendency of liquids to fish-eye.

Flashings: excess casting material squeezed out of the mould along the seam line.

Fome-Cor: a graphic arts board consisting of a sheet of foam covered with sheets of paper on both surfaces

Foredom tool: a hand-held, flexible shaft, electric tool with accessory bits for cutting, drilling, buffing, grinding and sanding. (Dremel is another brand name)

Frekote: brand name for a mould release agent used when casting epoxy in silicone rubber moulds

Glove Mould: a mould that is built up in layers to form a thin skin over the surface of the object being moulded

Hardener: a chemical added to a thermosetting resin for the purpose of curing or hardening (the terms hardener and curing agent are used interchangeably)

Heat gun: a hand-held tool resembling a hair dryer that can heat air to 360 F

Heat-shrink tubing: a flexible tubing made from a plastic with a "memory" that will return to its original size and shape when heated ; it is used in electronics to bundle wires

Hot stamping foil: a thin sheet of silver-coloured material which is coated on one side with an adhesive that becomes tacky when heated. The foil is generally applied to a surface with a heated roller

Lay-up: the process of placing and working successive layers of casting materials onto a mould by hand to build up a casting

Litho-aluminum: thin sheets of aluminum used in the lithography printing process

Microspheres: inert filler

Poured mould: a mould created by pouring material around an object fixed in a container

PVC: polyvinylchloride plastic

Release agent: a lubricant used to coat a mould to prevent the cast pieces from adhering to it, thereby easing the removal of the objects from the mould

Resin: solid or liquid organic compound made by polymeration. (For general purposes, the terms resin, polymer and plastic can be used interchangeably)

Rotational moulder: a mechanical device that rotates a mould while catalyzed resin forms a layer on the inside of the mould's surface and hardens, forming a hollow cast

RTV silicone rubber: two-part "room temperature vulcanizing" substance used for making moulds. RTV Silastic "J" and "E" are Dow Corning brand names for two of their formulations

Sculpy: a sculpting material similar to plasticine in appearance and consistency but which can be hardened by curing with heat

Silvering: a process of giving a metallic silver surface to an object such as a fish model

Toluene: a type of solvent

Vacuum former: a machine used to thermoform sheet plastics

Vacuum forming: a method of placing a heat-softened thermoplastic sheet over a mould then evacuating the air between the sheet and the mould so that the sheet conforms to the mould's contours

Vacuum chamber: a vessel from which the air can be evacuated using a pump

Working time: the period of time the substance remains workable as a liquid after mixing catalyst with liquid resin or mould-making material

INDEX

Acrylic optic fibres See: optic fibres

Acrylic rod, 5, 7, 8, 78, 80

Aerosil, 11, 13, 15, 17, 22, 23, 24, 28, 30, 31, 32, 35, 38, 39, 42, 43, 46, 56, 64-68, 73, 77, 78, 79

Aluminum lining bronze, 60, 62

Aluminum rod, 12, 73

Armatures 14, 16, 18; litho aluminum "ribs" 40, 41, 42

Attaching fins, 15, 25, 41, 43, 44, 46, 66

Bioluminescence, 62

Bioluminescent effect, 46, 48, 62
caudal flash, 50

Bolts, 25, 27, 28, 38, 40, 65, 67

Burlap, 42, 45

Casting, 1, 4, 7, 9-16, 19, 20, 23, 25, 31, 32, 33, 35, 36, 38, 39, 41, 44, 53, 56, 59, 60, 62, 63, 69, 71, 73-5, 77; casting wax 74; dam 19, 20, 30; fish-eyeing 9, 11, 39; hollow epoxy model 31, 32, 41-43, 62; oining pieces cast in two-piece moulds 10, 38; multi-colour lay-ups 28-30, 52-55 multi-layer model 76-79; PVC 69, 71-75; rotational molder 59-63; seams 10, 11, 15, 34, 35, 36, 40, 41, 44, 46; solid epoxy model 44, 53, 77

Calendered vinyl 72

Clamps, 12, 13, 14, 16, 58, 72, 74

Colour sketch, 13, 14, 16, 18, 20, 43, 46, 71, 72, 78

Compressed air, 6, 7, 8, 17, 22, 23, 33

Counter-colouration 60

Cornea 17, 18, 19, 20

Crazy glue See: cyanoacrylate

Curator, 12, 13, 15, 16, 18, 43, 46, 71, 72, 78

Cyanoacrylate glue, 46, 52,55

Dielectric fluid 33

Dorsal, 1, 5, 6, 7, 10, 11, 12, 16, 40, 45, 54

Dremel tool (Foredom tool), 13, 14, 15

Duvetyne fabric 70

E.L., 48, 50, 52, 53, 65, 66, 67, 68

Electro-luminescent lamp: See E.L.

Epoxy, 7, 9-18, 21, 23, 24, 26-32, 34, 37, 38-45, 47, 49, 50, 51, 54, 55, 63, 65, 69, 70, 75; bubbles 9, 29, 39; calculate volume 12; curing time 29; fish-eyeing 9; heat accelerated cure 13, 15; health hazard warning 10; inhibition of curing 29; lay-ups 13, 29, 34, 37; memory 13; multi-colour in the mould lay-ups 14, 16; Nu-clear epoxy 9, 15, 16, 24, 27, 29, 37, 38, 39, 43, 47, 49, 55, 56, 59, 75; pigment 29,30, 48, 52, 56; plug 45, 53, 76, 77 scraping 17, 56; Sun-Cure epoxy 39, 41, 44, 46, 53, 76, 79; "toffee" stage 9, 11, 29

Eyes, 17, 19, 47, 59, 64, 65, 66; cornea 18; iris 18, 47; lenses 18; pupil 18, 47; simple eye 47

Fibreglass :cloth 15, 23, 24, 26, 27, 28, 32, 38, 39, 41, 42, 56, 65, 67; mat 7, 10, 13, 15, 30

Finishing, 7, 13, 33, 41, 42, 54, 60

Fins, 4, 5, 9, 10, 13, 15, 21, 25, 29, 30, 31, 41, 43, 44, 46, 47, 55, 59, 62, 63, 65, 66, 68

Fish-eyeing, 9, 11, 39

Flo-out, 9, 11, 39, 56

Fomecor, 1, 7, 14, 35

Foredom Tool See: Dremel

Frekote, 10, 11, 16

Frekote 700 release agent See: Frekote

Heat gun, 9, 11, 19, 20, 22, 23, 29, 31, 32, 35, 36, 38, 39, 41, 49, 53, 70, 73, 77, 78

Heated roller, 60

Hot stamping foil, 60

Installation, 12, 20, 32, 46, 47, 51, 62, 69

Installation of an armature, 12, 14, 15, 18

Iridescent, 20, 39, 42, 43, 46, 55, 56, 60, 61

Iridescent powders, 55, 56, 60, 61

Jacket, 21, 23, 24, 26, 27, 28, 29, 31, 34, 37, 39, 40, 62, 75, 76 ; break 26 collars 23, 28, 39; dam 34; key holes 34, 35; keys 35

Lacquer spray paint , 56

Lacquer thinner, 13, 60

Litho-aluminum 21, 23-28, 37, 38, 39, 41, 42, 44, 45

Lock-tite See: cyanoacrylate glue

Microspheres, 39, 43

Mould, 1-13, 16-41, 48-50, 56, 62, 75-79; base mould 75, 77;calculate the approximate volume 10; dam 1,2, 5, 6, 9, 10, 17, 21, 23, 24, 25, 28, 76; flanges 21, 25, 67; freeform glove mould 23-25, 75, 77; glove mould 23-25, 29,33, 34-40; jacket 21, 23, 24, 26-29, 31, 34, 35, 37-40, 62, 75, 76; mould box 1- 6,8, 12, 48, 50, 71-3; mould-making material See: RTV silicone rubber; multi-layer model 76-79; one piece mould 1, 7; part lines 23, 25; pouring the mould 6-7; poured glove mould 26-30; registration 5, 6, 7, 8, 12, 17, 24; registration key holes 34; registration keys 7, 35, 36, 39, 58; seam lines 12, 16, 41, 56; two piece mould 4, 41, 49,56, 62; two-piece glove mould 33, 38, 40, 62; undercuts 4, 8, 22, 23, 27

Multi-layer model 76

Nylon stocking, 22, 35, 36

Oil paint, 13, 16, 43, 54, 56

Opaque coating 48

Opaquing paint, 42, 46

Opaquing pigments, 48, 62, 64, 65, 66, 68

Optic cable, 48-51, 65, 67, 68

Optic fibres, 47, 50, 51, 52, 63-66, 69

Organic vapour respirator, 8, 16, 69

Oven, 5, 9, 11, 13, 19, 20, 30, 31, 32, 48, 69, 70, 74, 75

Pectoral, 5, 6, 8, 13, 33, 46, 55, 56, 62

Photophores, 47, 50, 62, 63, 65-69

Plastic polish, 13, 15, 50, 66

Plastic wrap, 26, 27

Plexiglas , 24-28

Polyps, 71-74

Porous, 42, 45

Preserved specimens 1, 13, 43

PVC, 19, 69-74; assembling separately cast pieces 73; bubbles 72, 76; health hazard warning 69; lay-ups 70

RTV 615, 19

RTV Silastic "J", 33, 35

RTV Silastic "E", 23, 28, 75

RTV Silicone Rubber, 2, 4, 6, 8, 9, 19, 20, 21, 32, 49, 71; bubbles 4, 5, 8, 9, 19, 22, 23, 33; curing time 3; dielectric fluid (thinner) 33; heat accelerated 4; pigment 19, 21 ; toluene/vaseline release agent 7, 22, 27, 40

Registration (see Mould, registration)

Rheostat 62

Rotational molder, 44, 56, 57, 63

Scale model, 33, 34, 35

Scalpel blade, 13, 21, 24, 38, 40, 44, 46, 47

Scrims 44

Sculptures, 1-5, 7, 10, 17, 23, 57

Sculpy 1, 2, 4, 5-8, 10, 11, 12, 15, 16, 18, 19, 20, 21, 23, 24, 26, 27, 28, 33, 35, 37, 42, 43, 45, 48, 49, 56, 62, 65, 66, 69, 71, 73, 74, 75, 76, 77, 79; Sculpy dam 1, 5, 8, 9, 10, 21, 23, 25, 28, 38, 74, 75; Sculpy III 41; Sculpy model 33, 38, 40, 44, 56, 62, 71, 74, 75

Sight lines, 5, 32

Silicone rubber See: RTV silicone rubber

Silver powder See: aluminum lining bronze

Silvering technique, 58, 60

Slush molder See: rotational molder

Specimens, 13, 17, 43, 74

Styrofoam, 2, 6, 8, 25, 28, 33, 42

Styrofoam beads, 1, 2, 4, 21

Suppliers 81

Syringe, 11, 16, 29, 31, 40, 42, 46, 64, 72, 79

Tabs, 15, 30, 32, 35, 36, 43, 44, 51

Teeth 60

Tentacles, 21, 23, 24, 25, 29, 31, 62, 68, 69, 71-74, 78

Toluene/vaseline release agent, 7, 22, 27, 40, 49, 73, 75, 76, 77

Transparent dyes, 76

Turpentine, 13, 16, 43, 46, 50

Vacuum formed model, 46-48, 55, 56, 57

Velcro, 70

Vinyl, 42, 44, 45, 46, 47, 51-56

Vinyl sealer, 60, 61

Volume 2, 10

Wax
9, 26, 27, 28, 29, 70, 74, 75, 76

WD40 penetrating lubricant
74

Woodburning tool
62